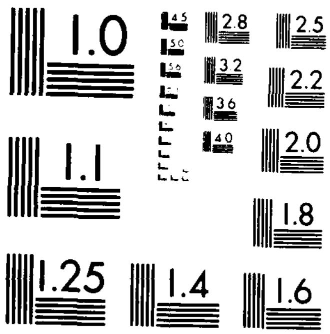
AD-A136 867 PROCEEDINGS: ECONOMIC AND SOCIAL ANALYSIS WORKSHOP HELD AT ST LOUIS MISSO..(U) ARMY ENGINEER INST FOR WATER RESOURCES FORT BELVOIR VA L G ANTLE OCT 83 IWR-83-P-40 1/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A136867

US Army Corps
of Engineers
Engineer Institute for
Water Resources

(12)

Proceedings

Economic and Social Analysis Workshop

25 - 29 October 1982
St. Louis, Missouri

Proceedings 83-P-40

COMPONENT PART NOTICE

THIS PAPER IS A COMPONENT PART OF THE FOLLOWING COMPILATION REPORT:

(TITLE): Proceedings: Economic and Social Analysis Workshop Held at St. Louis, Missouri on 25-29 October 1982

(SOURCE): Institute for Water Resources (Army), Fort Belvoir, VA

JAN 19 1984

TO ORDER THE COMPLETE COMPILATION REPORT USE AD-A136 867.

THE COMPONENT PART IS PROVIDED HERE TO ALLOW USERS ACCESS TO INDIVIDUALLY AUTHORED SECTIONS OF PROCEEDINGS, ANNALS, SYMPOSIA, ETC. HOWEVER, THE COMPONENT SHOULD BE CONSIDERED WITHIN THE CONTEXT OF THE OVERALL COMPILATION REPORT AND NOT AS A STAND-ALONE TECHNICAL REPORT.

THE FOLLOWING COMPONENT PART NUMBERS COMPRISE THE COMPILATION REPORT:

AD#:	TITLE:
AD-P002 631	National Waterways Study Waterborne Commerce Forecasts.
AD-P002 632	Overview: Navigation Systems Analysis Methods and Procedures.
AD-P002 633	System Equilibrium Evaluation Methodology.
AD-P002 634	Water Supply.
AD-P002 635	Water Supply/Conservation Planning Aids.
AD-P002 636	Port Analysis.
AD-P002 637	Operational Reality versus Engineering Design Standards in the Economic Evaluation of Harbor and Channel Deepening.
AD-P002 638	Evaluation of Agricultural Flood Control Projects.
AD-P002 639	Computerized Agricultural Crop Flood Damage Assessment System.
AD-P002 640	Review of Discount Rate Models for Evaluating Water Resources Projects.
AD-P002 641	Effect of Interest Rates on the Economic Analysis of the Gregory County Pumped Storage Facility.
AD-P002 642	Effects of the Discount Rate on the Civil Works Program.
AD-P002 643	Proceedings: A Meeting on the Evaluation of External Effects of Water Projects Held at Washington, DC on 21 September 1981.
AD-P002 644	Inflation & Measurement of the Opportunity Cost of Private Capital.
AD-P002 645	Economic and Social Analysis for Military Programs: The Fort Buchanan, Puerto Rico, Realignment Study.
AD-P002 646	Economic Analysis of Alternative Military Housing Accommodations.
X AD-P002 647	Economic and Sensitivity Analysis of Alternatives for Providing Family Housing. Executive Summary.
AD-P002 648	Damage - A Computer Program for Calculation of Average Annual Flood Damages for a Given Condition, or for a without-Project and a with-Project Condition with Resulting Benefits.
AD-P002 649	Regional Development Benefit Analysis for the Coosa River Navigation Project.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER IWR Proceedings 83-P-40	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Proceedings: Economic and Social Analysis Workshop		5. TYPE OF REPORT & PERIOD COVERED Proceedings of Workshop 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) L. George Antle, Editor		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Water Resource Support Center Institute for Water Resources Casey Bldg, Ft. Belvoir, VA 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Corps of Engineers Office of the Chief of Engineers 20 Mass. Ave., Washington, DC 20314		12. REPORT DATE October 1983 13. NUMBER OF PAGES 444
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release - Distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

U.S. Army Corps of Engineers, proceedings, planning, economics, navigation, hydropower, water, water conservation, water supply, flood control, social impact, interest rates, military housing, regional benefits, regional developments.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Papers presented at the Economic and Social Analysis Workshop held 25-29 October 1982 in St. Louis, Missouri on the subject of planning Corps projects with emphasis on the importance of economic analysis in project formulation and the recommendation of alternatives and a discussion of the content and context of the Principles and Guidelines.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Proceedings

Economic and Social Analysis Workshop

25 - 29 October 1982
St. Louis, Missouri

Water Resources Support Center
Institute for Water Resources
Casey Building
Fort Belvoir, Virginia 22060

TABLE OF CONTENTS

PAGE

INTEREST RATE/EXTERNALITIES

ECONOMIC AND SOCIAL ANALYSIS FOR MILITARY PROGRAMS

URBAN FLOOD CONTROL NONSTRUCTURAL

REGIONAL/CONSTRUCTION ERA IMPACTS

FOREWORD

Corps economists and social scientists perform diverse roles in managing and implementing the Corps planning for its Civil Works mission. A conference for Corps economists and social scientists, from time to time, provides an important communication and motivation opportunity. Dr. Blakey's keynote address emphasized that economists and social scientists are full members of the Corps multidisciplinary planning staff. They can become planning and program managers of new skills and interests, trend to management, or they can perform the numerous technical studies required for successful planning.

Emergence of the new Principles & Guidelines (P&G), along with the Regulation Reform Action Program (RRAP), is the primary motivation for this workshop. The importance of economic analysis in project formulation and recommendations of alternatives is stressed in the P&G. At the same time increased cost sharing of planning, construction and operations, and maintenance between Federal and non-Federal interests have increased the necessity for Corps planning to address the problems and alternatives that are within the interests and capability of non-Federal interests.

The Corps continues to provide leadership in articulating non-traditional (often called nonstructural) approaches to problem solving. Limited economic resources require more deliberate management measures which address all or part of the Nation's water resources problems. Economic and social analysts can supply productive skills in identifying and evaluating alternatives.

At every meeting of Corps economists and social scientists, the productivity and innovation of division and district personnel is demonstrated. They are the people who are confronted by the daily challenge to find workable answers to real water resources problems. Because of this tradition, the divisions were asked to develop and chair most of the sessions. Division personnel delivered interesting and challenging sessions, raised important issues, and suggested significant approaches to improve the problem solving capability of the Corps.

Several people from outside the Corps family made important contributions to the workshop. Dr. G. Edward Dickey (Senior Staff Economist for the Assistant Secretary of the Army for Civil Works), presented a timely description of the context and content of the Principles & Guidelines. The workshops on navigation (coastal and inland) were also enhanced by the presence of and presentations by shipping and state transportation interests.

The workshop was organized under the auspices of Robert Daniel, Chief of the Economics and Social Analysis Branch, Planning Division, Office, Chief of Engineers. His staff contributed much to the planning and implementation of the workshop. Workshop and program arrangements were managed by Dr. L. George Antle, U.S. Army Engineers Institute for Water Resources, with the substantial cooperation and assistance of the St. Louis District. The District Commander and Planning Division, especially the Economics staff, provided both administration support and a very successful tour to the construction site of the new Lock and Dam 26. Special thanks should also be given to the staff of the Market Street Holiday Inn in St. Louis, for providing friendly and competent support of the conference.

NEEDS ASSESSMENT

In order to obtain a better sense of the range of problems encountered by those doing or reviewing economic and social analyses, a needs assessment was performed. For this assessment the meeting participants were first asked to silently generate a list of the most important problems, questions or issues they had in performing or reviewing economic and social analysis studies for Corps projects. Next, participants were asked to work in small groups comprised of those sitting at each meeting table. Each small group was composed of three to four persons. Small groups were asked to review each persons list of problems, to discuss them, and from these lists to produce the three most significant problems for the small group. This process of reviewing the individual lists and developing a group assessment took approximatly 15 minutes. Finally, each small group presented its list to the larger group. These problems and needs were recorded on flip charts. After all entries had been listed, wording and definitional clarifications were made, and duplicates struck out. The following list represents the particpants statement of the most significant problems, needs and issues in performing or reviewing economic and social analyses for Corps studies.

Econ/Social Analysis Problems

1. Doing small area studies, using big area criteria.

2. Changes in regs, policies, especially when studies are nearly done.

3. Disenchantment of COE economists with Corps mission -- What is our mission?

4. Lack of continuity between districts in their benefit analysis (Flood, etc).

5. Personnel policies as they relate to economists -- training, pay.

6. Lack of guidance from higher authority -- too late -- until project is done wrong.

7. Plan formulation fragmentation -- economic input not successfully integraged.

8. Lack of consistent comments from OCE -- too much opinion, not enough policy.

9. Defining the without project condition explicitly enough to perform benefit analysis.

10. Monetizing resources not traditionally monetized.

11. What will our future work be as economists, and OCE?

12. Quantifying local and regional benefits in an acceptable manner.

13. Fragmentation: Economists view too routine and narrow-social scientists need to assert themselves in planning process.

14. Role of economists in financial feasibility studies -- mandated by Gianneli -- also in military studies.

15. We now use nominal interest rates -- we should use real.

16. Lack of guidance on: Updated vessel costs -- projected fleet recreation -- surveys.

17. No consistent guidance on growth by commercial contents and industrial contents.

18. Definition problem: Fine lines between financial, associated and economic costs.

19. Need for non-project -- specific funds to collect historical damage data.

20. We are now directed to choose NED Plan -- How to reconcile local preferences with this requirement.

21. Tunnel vision by various study components, division and OCE.

22. Limited funds and unlimited study criteria.

23. Conflict between economic analysis and real world financial analysis -- 50 year project life -- vs -- 5-10 private horizon, interest rates, etc.

24. Role of COE economists as consultants to local interests.

25. Conflict between NED optimization and SPF protection in urban areas.

26. Should NED plan be formulated unconstrained. (Public acceptance), etc.

27. Utilization of other social effects in planning reports.

28. Freeboard analysis should be separated between levee and channel related projects.

NATIONAL WATERWAYS STUDY WATERBORNE COMMERCE FORECASTS

Arlene L. Dietz
Manager, National Waterways Study

This term, forecasts, immediately conjures up mental pictures of beautiful math models and hungry computers. Most of you have certainly embraced one or more models during your career. Each probably discovered one or more major flaws or weaknesses in your models. The National Waterways Study (NWS) produced forecasts for every major United States waterway and for each major commodity group. NWS also produced a wealth of experience, learning from the successes and failures of the approaches and models. This presentation today will briefly discuss the NWS approach and touch on the success and failure of the forecasting effort.

DESIGN OF FORECASTS

The original NWS Plan of Study called for preparation of 10 separate forecasts of traffic for 66 geographical segments and for over 40 commodity groups. Each of these was to be based on several national-level macro economic models prepared by Data Resources Incorporated (DRI). These models embodied demographic, economic and policy assumptions. The output of these macro economic models was input into industry models which provided growth rates for key commodities moving in waterborne commerce. These industry models received input from DRI industry research groups, from industry interviews and Corps and public reviews.

The industry forecasts were then regionalized for production and consumption centers. Information on some commodities had to rely entirely on Corps experience since DRI had no industry research which could capture growth of very site specific movements (e.g. local sand and gravel). DRI also had to bridge the existing regionalization for specific industries into NWS segments and reaches. Particularly for this regionalization the value of Corps and public review proved itself. The review caught a conversion which placed major growth of soybeans in North Dakota.

The base historical waterborne commerce flows by commodity were for years 1969-1977. These data served as the base to apply regionalized industry growth rates. These growth rates were adjusted by the input obtained from industry regarding firm's logistics decision making process, new plant location or abandonment among others. The results of applying regionalized industry forecasts to waterborne commodity flows were forecasts for 22 reaches and 14 commodity groups for the period 1978-2003.

ECONOMIC FORECASTS REFINED BY SCENARIO ASSUMPTIONS

Scenarios assumptions (assumptions about external events which could greatly influence traffic growth and flows) were overlaid on the four base sets of economic forecasts to arrive at the final forecasts used in the evaluation of the system. The NWS report "Traffic Forecasting Methodology" provides the documentation of the economic forecasts while the report "Evaluation of the Present Navigation System" reproduces the output of the scenario forecasts.

All forecasts were to be unconstrained by waterway capacity contraints. These constraints were introduced into the evaluation phase along with solutions.

The scenario approach to forecasting sought to develop a wider breadth of forecasts by incorporating into the methodology plausible sets of policies and external events which would influence the growth of individual commodities. The assumptions of the seven scenarios (all major assumptions are shown in table 1) are as follows:

Baseline	This scenario continued past trends. Its only purpose was to serve as a reference benchmark. It was not intended to be the most likely. For example, future coal exports under this scenario show no growth beyond the 1980 level.
High Use	This scenario used the same micro economic assumptions for the nation as Baseline, but had greater levels of domestic and export coal movements. The Gulf's share of coal exports increased compared to Baseline.
Low Use	The Larger Government macro economic assumption was used in this scenario to influence a slowdown in the private sector and consequently waterway traffic. An unlikely assumption of no growth in corn yield, for example, was used to contribute to this low forecast. Crude oil imports dropped below both the Baseline and High Use levels Coal exports for year 2003 fell below the present level with the Gulf's share actually falling.
Bad Energy	The macro economic input was DRI's "Bad Energy" forecast. The economics assumed an energy crisis in the mid-1980's. Crude oil inputs dropped to a low of 200 million tons while coal exports and the Gulf's share were assumed to be the same as High Use. Domestic coal use was depressed below the Baseline reflecting a depressed economy. Seven coal slurry pipelines were assumed with one diverting over 4 million tons of water transported coal.
High Coal Export	The same macro economic forecast used for Baseline was assumed for High Coal Export. This scenario, unlike all others, assumed coal exports rising to 290 million tons by 2003. It had the Gulf's share of coal exports growing to 35 percent.
Miscellaneous	This scenario incorporates the High Use assumptions. Adjustments are made to account for data base errors not corrected in any other forecast base for the Ohio and Gulf Coast East reaches. It also introduced alternative forecasts for the Arkansas and the Columbia-Snake Waterway reaches.

Table 1

THE NATIONAL WATERWAYS STUDY PRINCIPAL ASSUMPTIONS FOR NWS SCENARIOS[1]

Principal Assumptions	Baseline	High Use	Low Use	Bad Energy	Defense	High Coal Exports
1. Macroeconomic	Trendlong	Trendlong	Larger Government	Bad Energy	Wartime Economy[2]	Trendlong
2. Corn Yields by 2003 (Bushels per Acre)	121	121	110	121	121	121
3. West Coast Share of Farm Products Exports (Percent)	14	14	14[3]	14	Overall Decline During Conflict	14
4. Phosphate Exports	Decrease After 1985	Constant After 1985	Decrease After 1985	Decrease After 1985	Constant After 1985	Constant After 1985
5. Steel Imports (Percent of Total Consumption)	Decrease After 1990 from 17 to 15	Decrease After 1990 from 17 to 15	Increase to 26 by 2003	Decrease After 1990 from 17 to 15	Decline Sharply During Conflict	Decrease After 1990 from 17 to 15
6. Crude Oil Prices (Average Annual Price Increase-Percent)	3.8	3.8	3.8	4.8	3.8	3.8
7. Crude Oil Imports by 2003 (Millions of Tons)	290	290	240	200	Decline of 100 Million Tons per Year During Conflict	290
8. Coal Exports by 2003 (Millions of Tons)[4]	107	156	107	156	156	290[5]
9. Gulf Coast Share of Total Coal Exports in 2003 (Percent)[4]	19	23	11	23	23	35
10. Domestic Coal Consumption by 2003 (Millions of Tons)	1,794	2,360	1,625	1,728	2,360	2,360
11. Synfuel Plants on Water (Coal Consumption in Millions of Tons by 2003)	10 (50)[6]	11 (61)	6 (30)[6]	15 (81)	11 (61)	11 (61)
12. Coal Slurry Pipelines	None	None	None	7[7]	None	None
13. Eastern Coal Use (Lake Erie Loadings of Coal by 2003 in Millions of Tons)	Present Technology and Regulations (20)	Present Technology and Regulations (22)	Increased Use in Great Lakes Area (24)	Present Technology and Regulations (20)	Present Technology and Regulations ([illegible])	Present Technology and Regulations (22)

1 The Miscellaneous scenario incorporates all the assumptions of the High Use scenario. The adjustments are made to account for data base errors (Ohio and Gulf Coast-East reaches) or to introduce alternative regional forecasts (Arkansas and Columbia-Snake Waterway reaches).
2 Based on Federal Emergency Management Agency forecast.
3 Great Lakes share drops 10 percent.
4 Overseas and Canadian destinations.
5 Based on National Coal Association high forecast and modified by Data Resources, Inc. (DRI).
6 An additional demonstration plant (not included in these numbers) on the Monongahela River is assumed in operation from 1983 to 1990 and consumes 3,000,000 to 6,000,000 tons of coal each year. However, after 1990, it is discontinued.
7 One of these seven pipelines (ETSI) will divert 4.5 million tons of coal from the waterways by 2003.

Defense - The macro economic forecast for a wartime economy was assumed. It shifts production and consumption from consumer oriented goods to defense materials. Petroleum and steel imports decline during the conflict. Domestic petroleum and iron ore and steel movements greatly increase.

CONCLUSIONS: FORECASTS AND THE METHODOLOGY

The output range by commodity by reach is provided in the NWS final report and in great detail in Appendix A to NWS report Evaluation of Present Navigation System. A summary of reach forecasts is shown in table 2. The generalized conclusions for the methodology and for the seven scenarios are discussed below.

The initial four scenarios - Baseline, High Use, Low Use and Bad Energy provided an inadequate range nationally and regionally for selected commodities (e.g. coal exports). Therefore, a fifth scenario, High Coal Export (HCX), was added. As designed in the Workplan, scenario development was to be based in part on public and Corps input. This would help reflect commodities not genrally modelled by DRI or those that were unique to a region. Consequently, the specialized traffic passing through the Inner Harbor Canal Lock (IHCL) and Columbia-Snake Waterway and on the Arkansas were reassessed in view of local knowledge. The results of this new information helped form the basis of a Miscellaneous scenario. Similarly, underestimates of Waterborne Commerce statistics were identified midway through the NWS for the Ohio River and several of its tributaries. The base traffic was consequently adjusted during this sensitivity analysis phase and was also reflected in the Miscellaneous scenario. The concept of allowing for not only post review revisions to basic forecasts but actually adding full scenarios based on the review process proved a valuable concept for such an involved national study.

The Defense scenario, always a key point in NWS, was the most complicated for DRI to produce. It was basically a major collection of sensitivity tests run on the High Use scenario for the 1985-90 period. This allowed for direct comparison with a peacetime scenario. Several reaches were surged with defense sensitive commodities. The greatest surge was at the Great Lakes Sault Ste. Marie Locks, next on the Ohio River and then on the Illinois Waterway. All three areas serve key iron and steel making centers of nation. The Gulf Coast petroleum movements increased under the scenario.

The NWS approach to forecasts aimed at establishing the boundary conditions for forecasts nationally, regionally and by industry regions. Because of the uncertainty surrounding world and national events which significantly influence the waterborne flows the scenario approach was selected. The sensitivity concept was incorporated to test newly identified events which would influence forecasts. The major finding regarding the expost analysis of the steps in the forecasting process was the real value of the thorough public and Corps review. Benefits were reaped from review of the methodology, of preliminary and final forecasts. The provision of adequate time for adding new information and changing forecasts proved to be invaluable step in the planning process.

Table 2
WATERBORNE COMMERCE: TOTAL OF ALL COMMODITIES BY REACH, 1977 AND SIX FORECASTS FOR 2003[1]
(Millions of Tons)

Reach	1977 Base Year	Forecast 2003 Baseline	High Use	Low Use	Bad Energy	High Coal Export	Misc.
Upper Miss.	30.9	66.0	68.7	58.8	67.9	68.7	69.4
Lower Upper Miss	77.5	162.0	167.3	147.7	163.3	169.6	170.7
L. Miss: Cairo to B.R.	123.6	222.3	231.0	190.7	235.9	246.6	248.4
L. Miss: B.R. to Gulf	344.4	534.9	548.7	492.1	543.7	591.4	570.4
Illinois Waterway	60.4	103.5	106.4	95.6	108.4	106.4	107.2
Missouri River	6.7	7.8	7.8	7.4	7.0	7.8	7.9
Ohio River System	172.5	307.5	345.2	280.3	324.5	359.6	382.9
Tennessee River	26.5	66.9	79.5	61.7	67.3	86.4	81.4
Arkansas River	9.4	14.4	15.0	10.8	16.5	15.8	26.2
Gulf Coast-West	341.3	385.7	389.0	376.9	362.2	404.1	391.5
Gulf Coast-East	108.7	152.1	168.2	141.3	140.5	168.5	177.9
Mobile River and Trib.	43.7	119.0	137.4	108.9	120.4	177.6	141.5
South Atlantic Coast	69.8	69.6	71.1	65.1	63.8	71.1	71.1
Middle Atlantic Coast	436.8	438.0	469.2	409.8	427.5	514.7	469.2
North Atlantic Coast	87.4	68.9	68.9	64.6	63.0	68.9	68.9
Great Lakes System	189.9	385.7	411.1	345.2	392.7	411.1	411.3
Washington/Oregon Coast	68.4	121.2	121.2	109.4	113.0	132.9	121.2
Columbia-Snake Waterway	43.5	58.6	58.6	57.9	54.6	58.6	63.7
California Coast	138.3	143.6	143.6	115.0	113.3	153.4	143.6
Alaska	28.8	86.2	86.2	86.4	95.4	86.2	86.2
Hawaii	15.3	21.5	21.5	20.9	21.1	21.5	21.5
Caribbean	89.8	74.5	74.5	49.4	68.0	74.5	74.5
Total[2]	1,914.9	2,585.6	2,727.2	2,379.8	2,514.3	2,889.6	2,789.2

1. Unconstrained forecasts of waterways tonnage.
2. These figures reflect national totals, not the sum of reaches. Reaches are not additive because many individual shipments pass through more than one reach.

Analysis of forecasts showed narrow bands of forecasts for certain commodities in certain regions. Further work in this area is needed as is the need to focus on this in future forecasting efforts. It may well mean that it is very certain that certain traffic levels will be achieved or it may imply a weakness in the methodology which did not generate wider spreads of traffic in each region.

The scenario/sensitivity approach offers an alternative to the traditional high-medium-low approach. It demonstrates there may well be a higher probabilities of very high (or very low) growth for certain commodities in some regions and hence provide strong support for scheduling of remedial actions.

CONTRACTING LESSONS

Contract problems was a topic the speakers were asked to address. Based on NWS experience the Corps should try to avoid, if possible, having prime/subcontractor arrangement where performance of one is linked to performance of another. The government is the looser for this arrangement. Many of the delays which occurred in NWS can be traced directly back to a failure of the sub or prime to produce data as scheduled. Although the contract limited the changes in key personnel, this clause was impossible to enforce. (e.g. one key performer, because of other obligations, was 7 months late in beginning his work).

Overview
Navigation Systems Analysis Methods and Procedures

Presented at
Economic and Social Analysis Workshop
St. Louis, MO
20 September 1982

By
Ron Keeney
Huntington District
Navigation Planning Support Center

The purpose this paper is to provide an overview of the inland navigation systems analysis procedures which are being used in the Ohio River Division (ORD).

The responsibility for system studies in ORD has been assigned to newly formed navigation planning support centers located in the Huntington District and the Louisville District. The Huntington center is responsible for economic system studies, while the Louisville Center is responsible for physical and environmental system studies.

A major systems analysis study was recently completed for the Phase I GDM on Replacement of Gallipolis Locks and Dam.

Development and application of the systems approach for the Gallipolis study was costly and time consuming. All of the districts in ORD together with the Division office contributed to this effort. However, with a common data base and analytic procedures in each of the four districts, it is now possible to perform system studies throughout the Division much more efficiently. The Gallipolis methodology, tools and data are now being used in navigation system studies at several projects in ORD including:

(1) L/D 52/53 on the lower Ohio River

(2) Lower Cumberland River

(3) Kanawha River

(4) Big Sandy River

(5) Monongahela River

(6) Emsworth, Dashields and Montgomery L/D's the Upper Ohio River

Significant applications also have been made in support of the O&M program, including assessments of reduced operating hours, and reduced government services at various locks.

The major problem in the economic evaluation of a lock and dam project is the interdependence of traffic flows among the many projects within the system. A change in the performance of one project can affect the efficiences of other components of the system in at least two ways: (1) By increasing service demands at the other structures and (2) by changing the economic and physical characteristics of the demand at other structures. Conversely, the capabilities of other components of the system can restrict traffic flows at the project under study and prevent the materialization of expected benefits.

Therefore, system studies which take into account these interactions are of major importance in the planning and design of navigation projects as well as their operation and management. Basically, systems analysis has three major objectives:

(1) Measure Total System Performance. First it is necessary to be able to measure total system performance in order to estimate the incremental benefits and impacts of a change to the system (e.g. larger locks). What is meant by system performance? Any number of variables can be used to describe how a project or system is performing, including tons or ton-miles moved, number of tows and barges locked, lock delays and processing times and numerous others. All of these are important.

However, the most important measure of system performance is system rate savings or the total savings in transportation costs for all of the traffic that moves. And, contrary to "conventional wisdom", the most efficient level of traffic on any given system is not necessarily the highest possible level. High traffic levels may result in delays and other inefficiencies of such a magnitude that total system savings could actually be increased by restricting traffic on the system.

(2) Measure Incremental System Benefits and Impacts. After measuring total system performance, the incremental system benefits for individual projects or plans are measured by varying the key operational variables such as lockage time, lock capacity and tonnage-delay relationships for the specific project being

considered and then tabulating incremental changes in system rate savings. The procedure is applicable to structural as well as nonstructural measures.

(3) Determine Optimum Plan. Benefits computed in this manner, which take into consideration the added system efficiencies created by the plan as well as any inefficiencies, form the proper basis for determining the economic optimum plan.

The Principles and Guidelines (P&G) for water resources planning (ER 1105-2-40) prescribes 10 major tasks or steps to be followed for economic studies of inland navigation projects, starting with identifying the study area and ending with estimating NED benefits.

These ten tasks can be conveniently summarized into three major types of economic studies.

(1) Commodity Flow Studies

(2) Transportation Rate Studies

(3) System Modeling/Benefit Studies

Specific efforts for each of these major studies for the Gallipolis Study will now be summarized.

The primary study area for each study was defined as the entire Ohio River navigation system. The system includes some 2,600 miles of navigable waterway controlled by 71 lock and dam projects along the main stem Ohio River and its major tributaries, including the Monongahela, Allegheny, Kanawha, Green, Kentucky, Cumberland and Tennessee Rivers. Based upon a study of the shipping patterns for Gallipolis traffic, this area was judged to be more than adequate for capturing any significant system impacts resulting from an improvement at Gallipolis. Additionally, this definition provided for a consistently developed systems data base for use in navigation studies in all four of the ORD districts, as this, too, was considered to be an important objective.

The commodity flow studies were concerned with analyzing existing and historical commodity flows and shipping patterns for the Ohio River system, and the projection of future barge traffic demands. For this analysis, several years of traffic data were obtained from the Waterborne Commerce Statistical Center in New Orleans. For study purposes, these data which reported detailed dock-to-dock shipments were aggregated in several ways to meet study needs. First, total annual traffic flows were developed between unique port/dock

pairs. Further aggregation was then performed to provide port equivalent-to-port equivalent flows (PE-PE) and BEA-to-BEA flows.

The individual 4-digit commodity tonnages were also aggregated to nine major commodity groups for study purposes. These three levels of geographic aggregation (dock, PE and BEA) provided basically all of the barge traffic data required to initiate the economic studies.

Obviously a major ingredient in any navigation study is the projection of future traffic demands. Three independent traffic projection studies were initiated for the Ohio River system, again through the cooperative efforts of the four district offices and the division office. Each study was performed by an outside consulting firm using separate projection techniques. The scope, complexity and timing of these studies was phased in such a manner that traffic projections were available during each key phase of the Gallipolis study and were commensurate with the level of formulation.

The studies in order of accomplishment and the responsible contractor include:

(1) Short-term commodity forecasts based on correlation and regression analysis of historical commodity flows on the system and regional growth indicators by Consad Research Corporation, Pittsburgh, PA;

(2) Short-term commodity forecasts derived through a structured survey of all system users by Battelle Memorial Institute, Columbus, Ohio; and

(3) Short- and long-term projections of traffic demands based upon a detailed market demand study, commodity resource inventory and modal split analysis for waterborne commodities in the Ohio River Basin by Robert R. Nathan Associates, Washington, D.C.

The end result of all three studies was an estimate of future demands on the system by commodity group and origin-destination area (PE and BEA). Specification of origin and destination areas was critical for later use in system studies as it permited tracing the flows through the system to describe traffic demands at each lock and dam. It must be emphasized however, that the projections represent traffic demands and not what can actually move on the system.

The second major element of the economic studies was transportation rate surveys, also developed for the entire Ohio River system. The objective of the rate

surveys was to develop a transportation rate matrix which described the rates and charges for each origin-destination traffic movement on the system. Obviously, it was not feasible nor desirable to perform detailed rate studies for every dock-to-dock movement. Consequently, statistical sampling methods were used to develop the rate matrix.

A sample of over 1500 individual dock-to-dock movements were chosen for detailed rate studies. Rates and charges were then developed for each of the 1500 movements for (1) the existing water-routing, (2) least costly all-overland routing, and (3) alternative land-water routings. The firm of Charles Donley and Associates conducted the necessary rate studies for the sample movements.

Rates for all unsampled movements were subsequently developed using the data for the 1500 sample movements and well established statistical methods. For each commodity movement on the system, the matrix describes 4 key items of information:

(1) The existing barge line haul rate per ton,
(2) All other charges associated with the existing water-routing, (e.g. loading, unloading and transfer charges and any prior or subsequent overland hauls),
(3) The total transportation cost per ton for the existing water routing (sum of above items; and,
(4) Total transportation charge per ton for the least-costly overland routing.

The segregation of the barge line-haul rate from the total water-routing cost was critical to our systems analyses. As will be stated momentarily, the barge line-haul rate is the only portion of the total water-routing charge which is assumed to change in future years in response to changes in systems use (e.g. tonnage) or a change in the system itself (new lock).

At this point, then, it is known what future demands are likely to be and the relevant rates for shipping in the present market. In order to estimate how much of the future demands could actually move by barge, it was necessary to have some knowledge of future barge shipping costs relative to overland modes.

As waterway traffic increases through time, congestion will cause additional delays and result in increases in barge rates. Traditionally, in navigation studies it had been assumed that future increases in barge rates

would be matched by increases in overland rates and, therefore, today's rate differentials would remain constant over time. Current policy does not permit this simplifying assumption with regard to barge rates. It requires an assessment of future system delays associated with the projected traffic volumes and the impact of those delays on barge rates. Current policy does, however, permit the assumption that overland rates will remain unchanged through time, and this assumption was used in the analysis. The task, then, was to develop a procedure for evaluating the incremental impact of a single improvement in the system (new locks at Gallipolis) which uses prevailing rates and at the same time realistically considers the impact of future system congestion.

The "model" utilized by the Huntington District in estimating future barge line-haul costs, rate savings and traffic levels, was the Tow Cost Model and a number of supporting programs. The Tow Cost Model is actually a refined and expanded version of the Flotilla Model which was developed under the Corps' INSA program. It was later modified by the Department of Transportation for use in their initial user charge studies and further refined by the Huntington District for the Gallipolis study.

The Tow Cost Model is a set of computer programs and data files designed specifically for use in system-wide navigation economic studies. Using detailed input data which describes (1) the waterway system being evaluated, (2) the equipment used for towing operations, (3) the costs to industry for owning, operating and maintaining the towing equipment, and (4) the commodity flows and shipping patterns on the system, the model calculates the towing equipment required and the cost for moving the traffic.

The number and types of barges and towboats are selected by the model on a least-cost basis. The least-cost means of shipment for each origin-destination movement is determined by the model by evaluating the costs for all possible shipping plans and allowable tow sizes. The costs are determined by first tabulating the time required for the logical combination of events needed to move the tow from the shipping point to the receiving point, accounting for interaction of tows at commonly shared facilities such as locks. The major time elements include (1) time spent loading and unloading barges, (2) tow transit time in open river situations, (3) lockage time and lock delay, and (4) time spent in refleeting operations. These times are then translated into the cost of transport by application of equipment costs per unit

of time which is input to the model. These costs are obtained from the annual equipment cost surveys conducted by the Water Resources Support Center and verified through contacts with local shippers.

Input data necessary to run the Tow Cost Model is large. The major items of required data include:

(1) Waterway Physical Description
- Rivers & River Segments (Length, Depth, Velocity)
- Locks (Location, Capacity, Lockage Time, Delay Function)
- Ports (Location, Loading, Unloading & Fleeting Times)
- Refleeting Points (Location & Refleeting Times)

(2) Towing Equipment Descriptions
- Towboats (Physical Dimensions, Horsepower, Fuel Consumption Rate, Fuel Price, Operating Costs)
- Barges (Physical Dimensions, Capacity, Costs)

(3) Commodity Transportation Class
- Commodity Names
- Handling Class (e.g. Dry Bulk, Liquids, Speciality Products)
- Density
- Value/Ton
- Barge Type
- Inventory Holding Costs

(4) Commodity Shipment List
- Commodity Name
- Origin Port
- Destination Port
- Tonnage By Season
- Percent Dedicated Equipment

(5) Waterway User Charge Specifications
- Federal Costs By River
- Costs to be Recovered by River
- Collection Mechanisms
  - Lockage Fees
  - Segment Tolls
  - Fuel Tax
  - Tow and Barge Registration Fees

The primary output from the Tow Cost Model is a file which contains data describing the costs for each

origin-destination movement. Hard copy reports are also provided which summarize the model results, including:

(1) Annual Towboat Utilization and Costs
(2) Annual Barge Utilization and Costs
(3) Tow Size Distribution
(4) Lock Utilization
(5) Lock Costs
(6) Port Utilization
(7) Port Costs
(8) Segment Cost Summary
(9) User Charge Summary
(10) Fuel Tax Analysis
(11) Lockage Fee Analysis (not pertinent to this study)
(12) Segment Fee Analysis (not pertinent to this study)
(13) Registration Fee Analysis (not pertinent to this study)
(14) Tow Speeds by Waterway
(15) Tow and Barge Loading by Class at Desired Locks
(16) Number Loaded Empty and Total Barges By Class at Desired Locks
(17) Towboat Size Distribution at Desired Locks

The movement-specific costs which are produced by the Tow Cost Model are used by supplemental post-processors to adjust barge line-haul rates and rate savings through time. This is accomplished by computing the percent change between present and future modeled costs for each origin-destination commodity movement and making corresponding adjustments in the existing barge line-haul rate as determined through the rate survey. The revised line haul rates are then added to the other (fixed) components of cost stored in the base rate matrix to yield a revised total water-routing cost for each movement.

The revised total cost for each movement is then compared with the base overland rates to determine the revised rate savings. The post-processor then ranks all of the movements in the input shipment list from highest-to-lowest unit savings and provides running totals for system tonnage, ton-miles, total water-routing costs and total system rate savings. Similar rankings are provided for the subset of system traffic that transits Gallipolis Locks.

Having defined existing and future demands for waterway traffic, existing transport costs by barge and the least costly alternative, and a method for estimating future barge shipping costs, the remainder

of the evaluation involves application of supply-demand analysis to estimate the level of system performance under with and without plan conditions.

Since the model is designed to represent static conditions, the important element of dynamics in the supply-demand analysis is interjected through repetitive model runs. The primary objective in the supply-demand analysis is to define the equilibrium level of system traffic for "with" and "without" plan conditions and the associated system rate savings. Equilibrium traffic levels means that level of system use at which average system rate savings for the last added movement just equals the average system towing costs. Theoretically, tonnage would not exceed this point since cheaper transport alternatives would be available.

For basically all future year model runs, it was found that system traffic demands exceeded the equilibrium level, resulting in prospective negative rate savings for many movements. Since these uneconomic movements impact the efficiency of all other movements with common routings, it was necessary to delete these movements from the input shipment list in small increments and repeat the modeling process.

Movements were selected for diversion from highest-to-lowest dis-savings. The diversion process was repeated until the system traffic level was reached at which all movements exhibited a positive average rate savings.

This process was used to define the equilibrium traffic level for each decadal traffic projection and each project change being evaluated at Gallipolis. Gallipolis project changes evaluated include increased capacity at the existing facility by implementation of non-structural measures and by the addition of new lock structures. Non-structural measures, including helper boats also were evaluated at other congested locks in the system as conditions warranted. By varying the model input parameters such as lock capacity and lockage time one at a time to reflect these improvements, incremental differences in system performance assignable to each improvement were estimated.

Potential benefits for a lock congestion fee at Gallipolis also was evaluated. This was accomplished by diverting additional increments of Gallipolis traffic beyond the equilibrium level until the point was identified at which marginal towing costs equaled rate savings (social optimum traffic level). The

difference in system rate savings between the equilibrium and social optimum traffic levels represent the benefits for the congestion fee.

NED benefits for each alternative were then determined by constructing a time series of system rate savings for the without plan condition and for each plan of improvement from the model output. These values were then used to calculate the incremental system rate savings attributable to each alternative over time. Average annual benefits were then computed by converting these values to equivalent annual amounts.

NED costs were computed in a similar manner. Costs for the with and without plan conditions include all actions required to produce the system rate savings that were measured for each condition. The incremental costs for each Gallipolis replacement alternative represents the difference between "with" and "without" plan system costs.

Once the modeling process was completed, sufficient data had also been generated for system impact evaluations. Data are readily available to evaluate the impact of each alternative on (1) total system traffic levels, (2) traffic at critical projects, (3) system lock delays, (4) delays at other critical projects, and other variables.

Data are also available on the specific commodities diverted from overland transport modes under each alternative including annual tonnage and origin-destination points.

These data together with information on the financial and operating characteristics of affected modes can form the basis for overland mode impact assessments.

In addition to its value in basic formulation, the model also can be used to evaluate the sensitivity of the recommended plan to:

(1) Alternative Traffic Demand Scenarios;
(2) Changes in Overland Rates;
(3) Changes in Barge Rates;
(4) Changes in Fuel Prices;
(5) Future Lock Improvements Elsewhere in the System; and
(6) User Charge Recovery.

Concerning user charges, the Principles and Guidelines require that a sensitivity test be performed to determine the impact of 50 percent and 100 percent recovery of system costs.

The guidelines further specify the use of a fuel tax as the collection mechanism. A uniform system-wide tax was assumed for the analysis. Segment-specific fees were not evaluated. The costs to be recovered were defined as the without and with plan system costs that were discussed hereinbefore.

Starting with the equilibrium traffic level in each decade for the without plan condition, an initial estimate was made of the fuel tax required to recover 50 percent of the without plan costs. This tax was then input to the model and the equilibrium traffic level was re-ran. The model output was then inspected to determine if the target recovery level had been achieved and whether or not there were any uneconomic movements at the higher shipping costs. If uneconomic movements were found, they were then diverted in the same manner as previously stated and a new tax was estimated for the lower traffic level.

This process of gradually increasing the tax and diverting uneconomic traffic was repeated until the model showed sufficient revenue being generated to recover first 50 percent and then 100 percent of without project costs in each decade. The same steps also were used to estimate the required tax for recovery of with plan costs. The incremental system-wide taxes necessary to recover 50 percent and 100 percent of the incremental annual costs for the plan recommended in the Gallipolis report were then estimated by comparing the without plan and with plan taxes in each time period.

In summary it can be stated that:

(1) Even though initial obstacles appeared to be formidable, systems analysis can be performed with available technology and a tremendous amount of work;

(2) The analysis can be tailored to provide results that can be easily and effectively incorporated into project-specific formulation;

(3) Although Gallipolis is the most critical bottleneck in the Ohio River system, several other locks were found to be problem spots early in the planning period and prevented the full realization of the benefit potential at Gallipolis for all of the plans that were evaluated;

(4) Nonstructural traffic management measures can provide sizable benefits in relation to the benefits for lock replacement alternatives;

(5) Even though the model is a very valuable tool, the key elements of the analysis are the traffic projections, the rate studies and the lock capacity analysis. Therefore, study efforts should focus on these items, at least early on in the study;

(6) Considerable time should be spent early in the evaluation in scoping the system to be studied, tailoring the data collection efforts, and in calibrating and testing the model.

(7) Accurate and consistently collected PMS and WCSC data are absolutely essential to proper system evaluations.

SYSTEM EQUILIBRIUM EVALUATION METHODOLOGY

Donald Sweeney, Regional Economist, St. Louis District

1. Model Rationale and Methodology

Measurement and allocation of transportation savings, benefits and costs for alternative system configurations in the Upper Mississippi River Basin requires the consideration of several important issues. Foremost amongst these issues is the inter-relationship between locks in the system and the manner in which alterations at one lock affect the operational performance of the entire navigation system. This issue is generically referred to as systems analysis and is concerned with the analysis and description of impacts within a system resulting from the modification of some portion of the system. From an analytical viewpoint, it is useful to conceptualize systems analysis as a delineation of the scope of impacts that a model is designed to address rather than as a specific model that must be used in evaluation.

Once a framework for a systems analysis is selected, two issues surface that impact the efficacy of this framework. The first is concerned with data availability and accuracy for use in this framework. For example, data on tonnage volumes shipped on the waterway are readily available. However, the true origins or destinations of these shipments and their associated transportation rates charges are not, so that the availability and accuracy of information on these data items must be evaluated. The second issue concerns the construction and solution of a model based on this framework.For example, how large is the system which the model must encompass and what constitutes a solution to the model?

The data issue is addressed in earlier sections and will not be dealt with here. The second issue does impact on the construction of the systems analysis model and is a focal point of this section. The remainder of this section will discuss the theoretical underpinnings of the model developed and used in this study and the nature of the solution generated by this model. For purposes of tractability we begin this discussion by focusing on a one lock system and then expand the discussion to the nature of relationships between locks that need be satisfied within the systems analysis framework.

Evaluation of a One Lock System

The basic evaluation framework of navigation projects is an examination of incremental project benefits and costs under the "with" and "without" project conditions. Costs of the project represent construction, operating, and maintenance outlays associated with the project and are not included in the modeling of benefits directly. This is simply a function of the cost recovery mechanism currently in effect on the waterways, although conceptually these costs can be incorporated into the modeling of benefits with various alternative cost recovery mechanisms.

Benefits for navigation projects consist of two components, transportation savings and lock delay reductions resulting from a navigation improvement. For example, let the demand for lock usage be a function of transportation costs by various modes and lock supply a function of the operating characteristics of a particular lock. When demand for lock usage exceeds the available supply of the lock, some traffic cannot utilize the lock. In particular, as the amount of traffic passing through a lock increases, delays at the lock increase due to increased levels of congestion. This raises the cost of transportation on the waterway. At some point the increased costs will exceed those of some alternative mode for some movements, and shippers of these movements will find it more economical to use an alternative mode.

This idea is graphically demonstrated in Figure 1. The damand curve DD shows for each ton of commerce desirous of lockage the difference between total water transportation costs with no lock delays and the total costs of movement via the next least costly alternative mode of shipment. This difference will be called the Gross Rate Savings of that ton's potential movement via the waterway. The supply curve SS is simply the delay costs incurred by each movement as different levels of tonnage transit the lock. It is upward sloping to represent the notion that as more tons pass through a given lock, greater levels of congestion occur, and consequently, higher per ton costs of delay are incurred. The equilibrium price or congestion cost is P with tonnage of T actually transiting the lock. All tonnage to the "left" of T find it still cheaper to move on the waterway than on the next cheapest alternative mode, whereas all tonnage to the "right" of T find it economically more advantageous to use some transportation mode other then the waterway. Hence, T tons will pass through the lock and incur congestion costs of P dollars.

This simple model can be expanded to illustrate the computation of project benefits under the "with" and "without" project conditions. Let S be the "without" project supply and S' be the "with" project supply curve for the lock. Since navigation projects are undertaken to alleviate waterway constraints, S' lies to the right of S. That is, for a given level of tonnage transiting the lock lower levels of congestion costs are incurred per ton under the "with" project condition. For each condition the benefits are the total gross rate savings for traffic traversing the lock minus delay costs associated with that level of traffic. Thus the incremental benefits associated with S' are the increased net transportation savings of any increase in traffic plus any delay reductions for traffic that traverses the lock under the "without" condition. In Figure 2 the transportation savings are represented by the area ABC and the delay reductions by the area ACP_1P_0.

Effectively, this methodology will eliminate movements by origin-destination in a systematic fashion. The level of lock delay time in relation to the gross rate savings, including accessorial costs, is

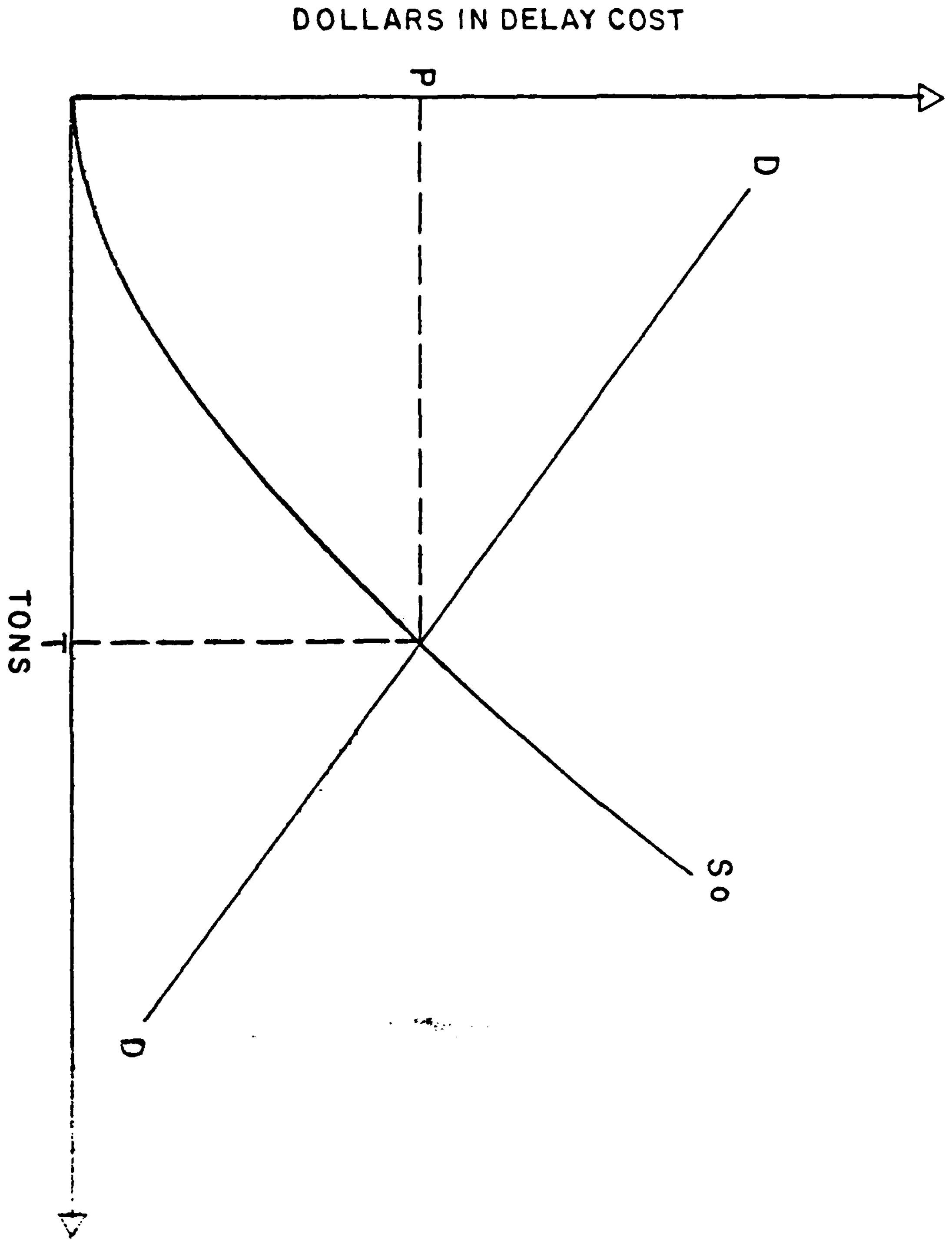
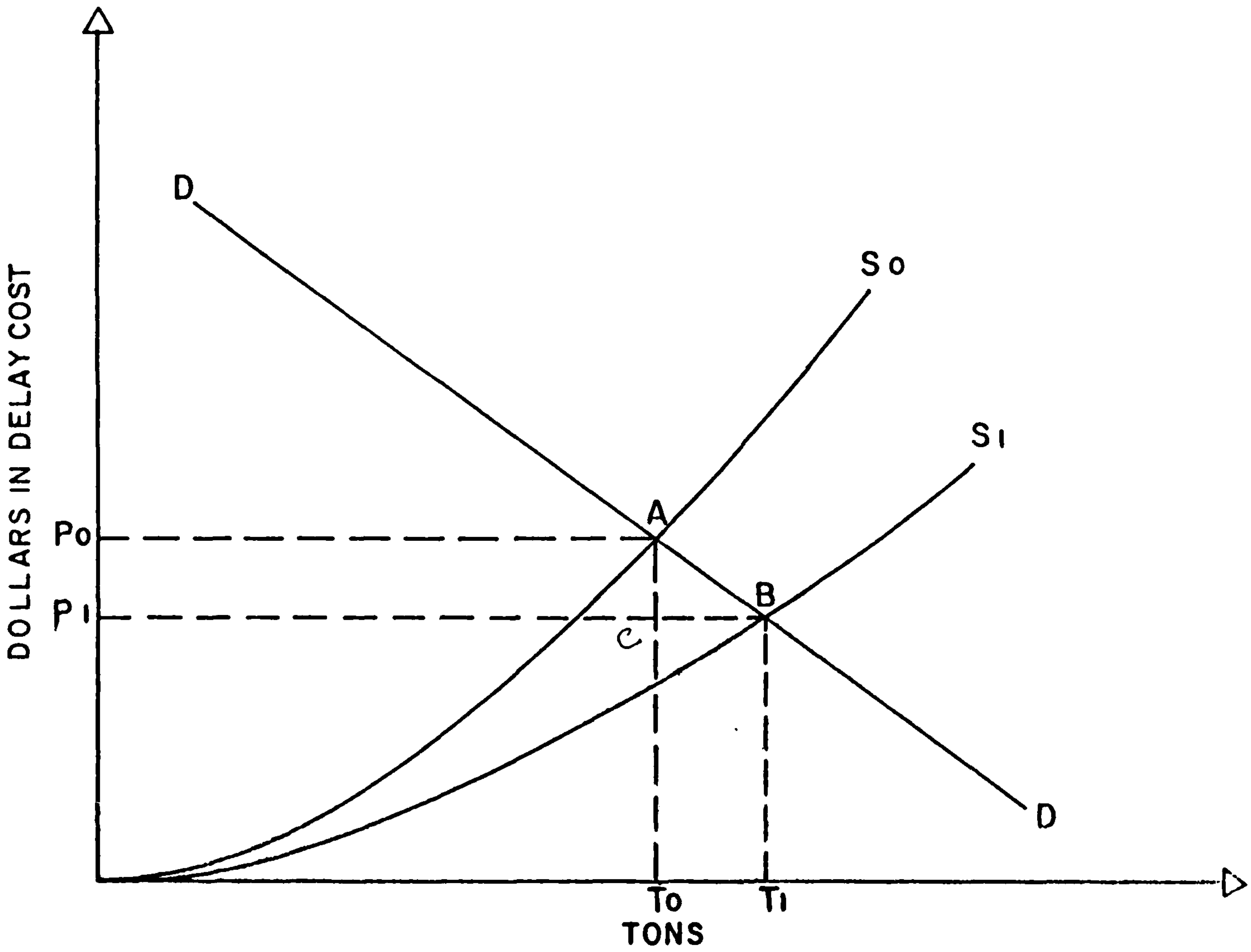


FIGURE I

FIGURE 2



used as the economic variable to divert traffic from the system. This rationale stems from optimizing behavior on the part of shippers and carriers and the nature of the lock supply curve. (As high levels of lock utilization are reached, the delay costs at the lock will increase due to increased levels of congestion). Assuming that shippers are price takers, the increased delays will increase their shipping costs on the waterway. At the point where the gross rate savings on the waterway equals the delay costs on the waterway, the shipper is indifferent between various modes. However, any additional delays will make it less costly to utilize some alternative transportation mode and the movement will be diverted from the waterway.

Evaluation of System With More Than One Lock

The evaluation methodology for a one lock system is straightforward and can be conceptually extended to the evaluation of a system with two or more locks. However, this evaluation requires that the total system be modeled simultaneously. That is, the equilibrium at each individual lock, as discussed above, is dependent on the equilibrium at every other lock included in the system. This results from multi-lock movements in the system tying together the demands at the individual locks. Thus the determination of any individual lock equilibrium requires knowledge of the equilibrium at all locks in the system. While the conceptual basis of measuring benefits is the same for both cases, the consideration of a multi-lock system requires the use of significantly more advanced computational techniques than need be applied to the single lock system.

The need for more advanced computational techniques is rather easily demonstrated. In a single lock system, demand is specified as a function of transportation rates (total transportation cost differentials) with no demand effects arising from other components of the system. This is an obvious simplification unless there is no multi-lock traffic utilizing a particular lock, which is certainly not the case for the majority of locks on the Upper Mississippi River System. Effectively, this specification ignores other system components under the assumption that modifications at one lock do not significantly affect any operational aspects of other components in the system. For small changes at a particular lock, this method is probably sufficient and is certainly a method whose use is supported by the bulk of theoretical work performed in microeconomics. However, with rather large changes in a system, the assumption that systems effects are quite minor becomes much more difficult to rationalize, requiring an explicit consideration of other system components and the relationship between system components.

The increased sophistication necessary in this evaluation stems from the fact that (i) a movement will divert from the waterway when total systems delays for the portion of the system used by the movement exceed rate savings, rather than delays at only one lock, and (ii) the delays and traffic computed for each component for the system must be logically

FIGURE 3A
LOCK I

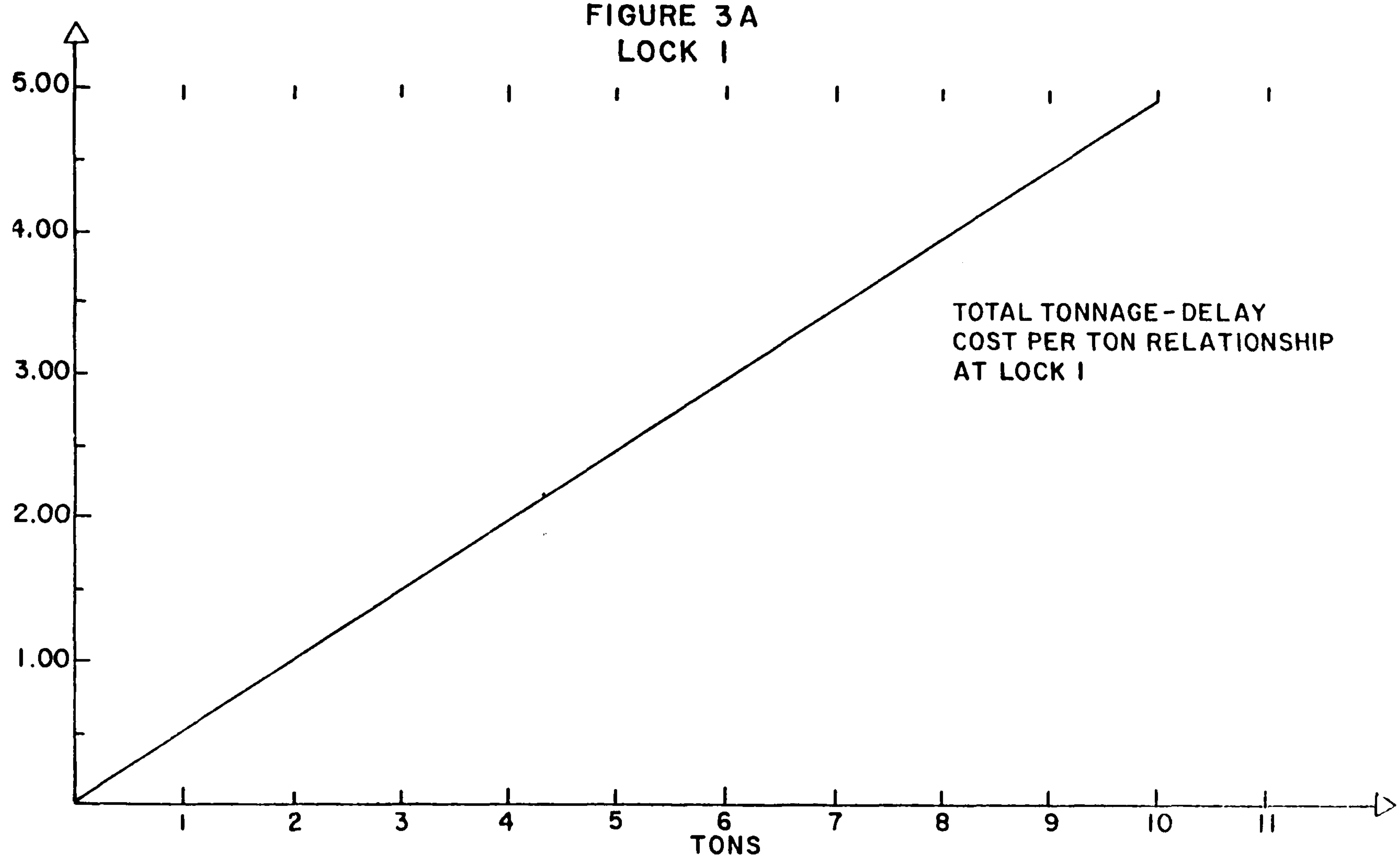


FIGURE 3B
LOCK 2

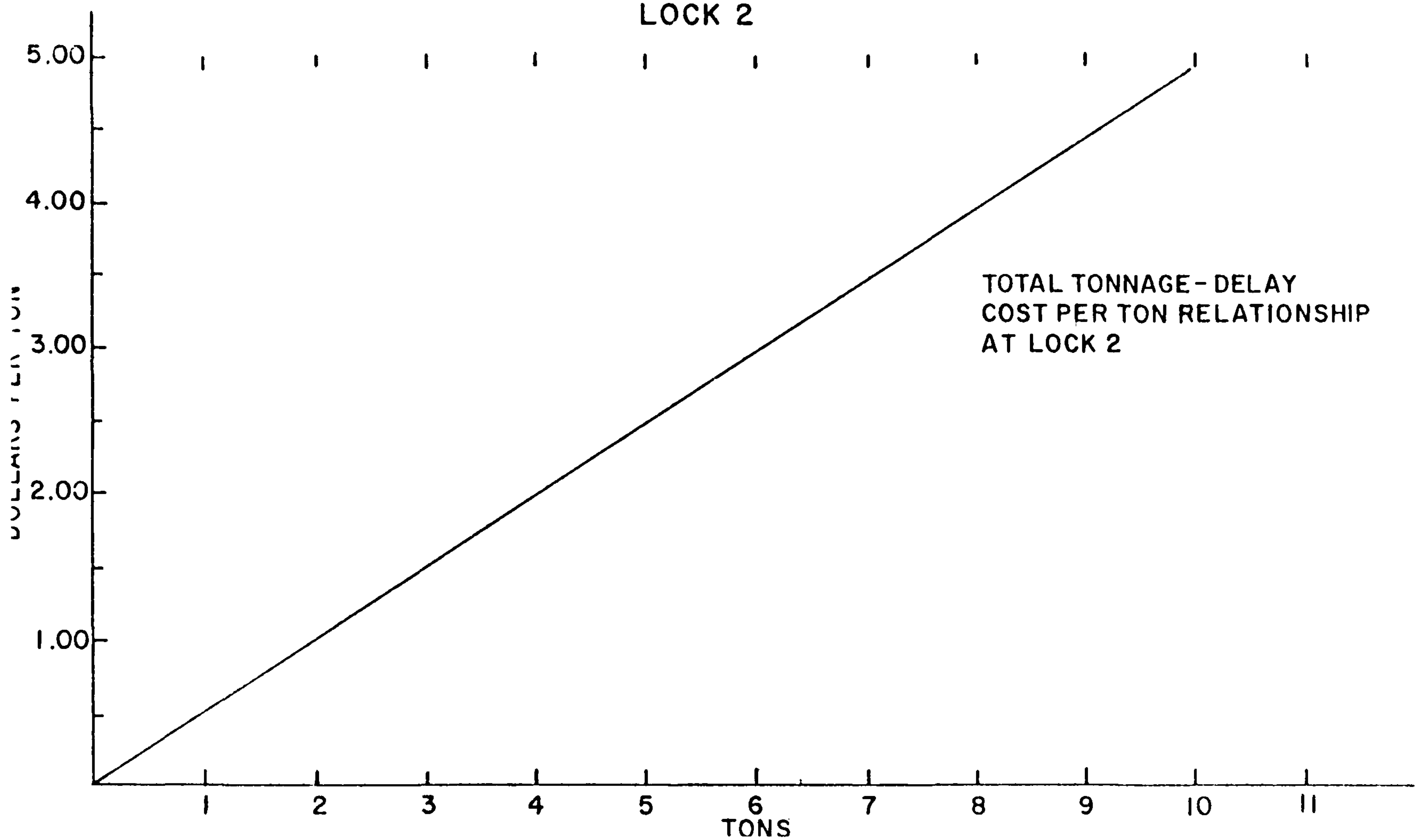


FIGURE 4A
LOCK I

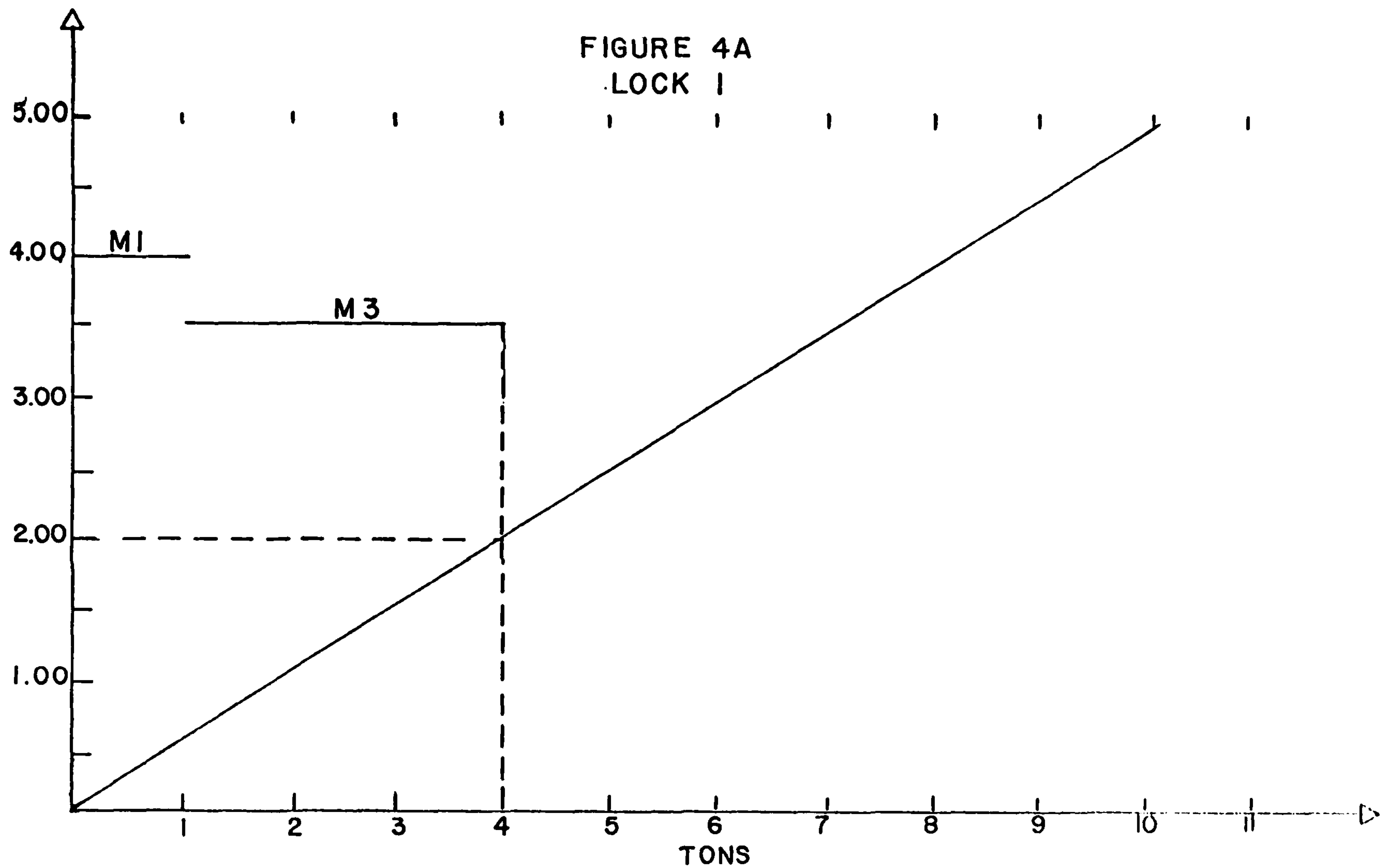
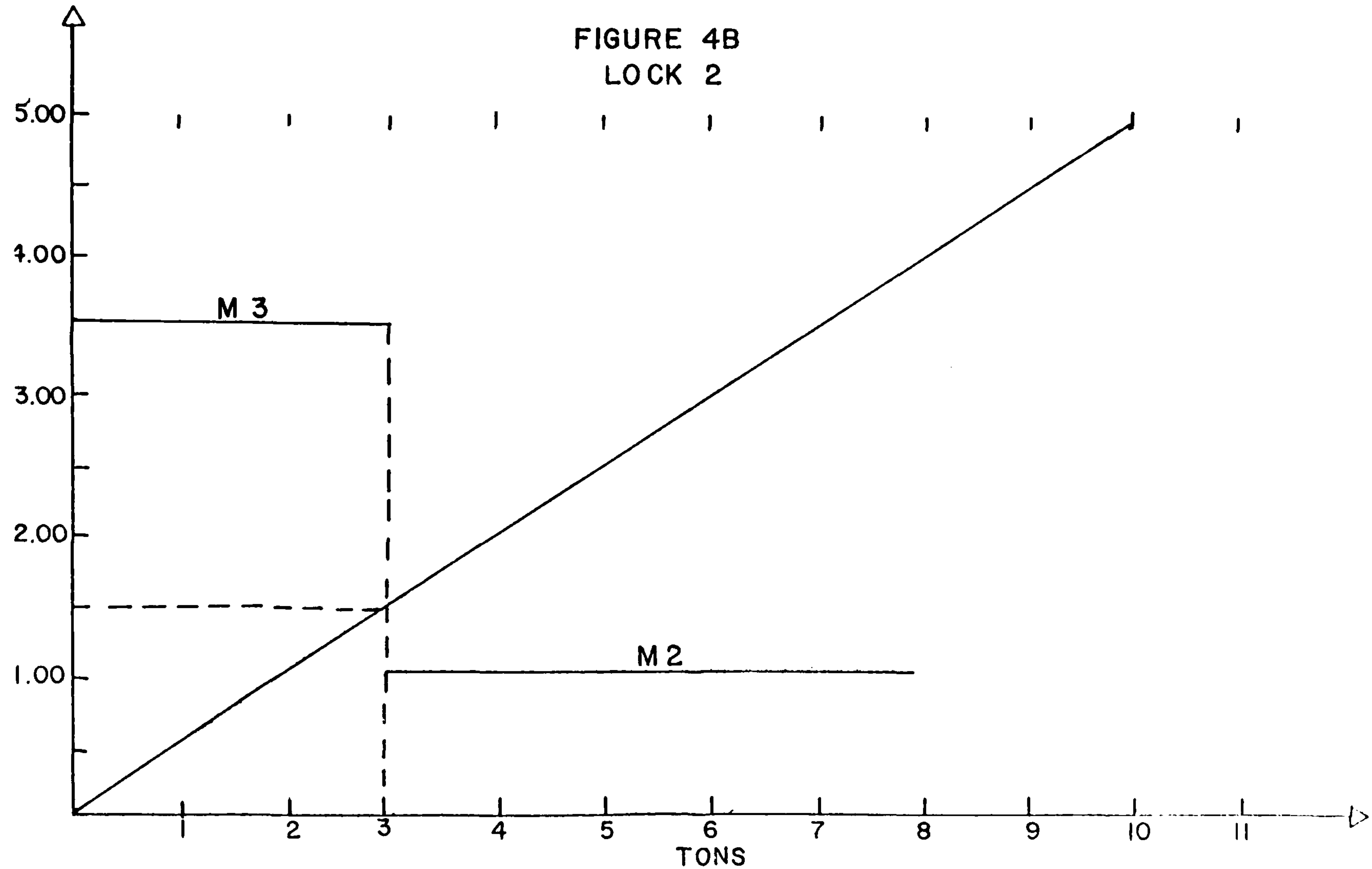


FIGURE 4B
LOCK 2



consistent with the delays and traffic computed for all other locks in the system. This requires that the equilibration at all system component take place simultaneously. In the evaluation procedure used in this analysis, this simultaneous equilibration is achieved through the use of a computer algorithm based on fixed point theorems. Effectively, the results at each individual lock are exactly like the single lock case, but they incorporate the fact that the equilibrium at each lock must exist jointly with equilibrium in the system as a whole.

Model Operation and Use

The workings of the algorithm can best be illustrated in a simple two-lock system example. Without loss of generality, assume that the two locks in the system have identical capacities and supply (tonnage-delay cost) relationships as shown in Figures 3a and 3b. Now suppose there are three potential movements desirous of using the sytem and again for simplicity's sake assume the movements are all of the same commodity. Let movement number one consist of one ton, have a gross rate savings of $4.00 per ton, and be desirous of using only Lock 1. Let movement number two consist of five tons, have a gross rate savings of $1.00 per ton, and be desirous of using only Lock 2. Finally, let movement number three consist of three tons, have a gross rate savings of $3.50 per ton, and be desirous of using both Lock 1 and Lock 2.

To determine the system equilibrium (i.e., the equilibrium at each lock consistent with each other) the algorithm begins by computing the equilibrium at each lock assuming that there is no delay costs anywhere else in the system. This is illustrated in Figures 4a and 4b. First, notice only movement three appears in both demand curves as it is the only movement desirous of using both locks. From the figures it is readily apparent that at Lock 1, all four tons demanding lockage will use the lock and incur delay costs at that lock of $2.00 per ton. Similarly, at Lock 2 only the three tons of movement three will use the lock and incur a delay cost of $1.50 per ton. Here movement two will find it cheaper to divert from the waterway to its next cheapest alternative mode, as the delay costs incurred outweigh the gross differential it enjoys.

Note that while each lock is in equilibrium individually, collectively a systematic equilibrium has not necessarily been achieved. This is the case because the equilibrium level of delay costs at each lock was derived upon the assumption of zero delay costs at the other lock. The equilibria just computed are, however, upper limits on the system equilibrium levels of delay. That is, any mutually consistent equilibria for the two locks must be less than or equal to those just computed, as it was assumed that no delay costs are incurred by lock movements even if they move through other locks.

The next step in the algorithm is to pose the question: "What would be the equilibrium levels of delay costs at each lock given that the other lock had a level of delay cost equal to its just computed upper limit?"

The derivation of the two new equilibria is depicted in Figures 5a and 5b. Since movements one and two use only Lock 1 and Lock 2 respectively, their demand for use of each lock is unaffected by delay costs elsewhere in the system. However movement three can only withstand lower delay costs at each lock. Since it has a gross rate savings of $3.50 and by assumption incurs delay cost of $1.50 at Lock 2, it can only withstand $2.00 of delay costs at Lock 1. Similarly, since by assumption it incurs $2.00 of delay cost per ton at Lock 1 it can only withstand $1.50 of delay costs at Lock 2 before diverting. Hence the new demand curves are formed as depicted in Figures 5a and 5b. The resulting equilibrium at Lock 1 again shows all four tons will move at a delay cost of $2.00. At Lock 2 only movement three will move and incur a delay cost at that lock of $1.50.

Now, as the two equilibria just computed were based on the assumption of "maximum" delay costs elsewhere in the system, they must be a lower limit on potentially consistent equilibrium. That is, any mutually consistent equilibrium levels of delay costs at Lock 1 and Lock 2 must be greater than or equal to $2.00 and $1.50 respectively. But we have already demonstrated above that the upper limit on consistent equilibrium delay costs are $2.00 and $1.50 at Lock 1 and Lock 2 respectively. Hence, it must be true that $2.00 and $1.50 are the mutually consistent systematic equilibrium delay costs. (If at this point the upper limits and lower limits weren't the same, the algorithm would continue by computing a new upper limit on the quilibrium delay costs by assuming that delay costs elsewhere in the system were equal to their newly computed lower limit, and so on, until either the upper limits equal the lower limits or no further improvements can be made on their agreement).

The computation of net benefits is now readily completed. Movement one, consisting of one ton, has a gross rate savings of $4.00, but incurs delay costs of $2.00 per ton at Lock 1 and hence has a net transportation rate savings of $2.00 ($4.00-$2.00) per ton. Movement two diverts from the waterway and consequently receives no benefits. Movement three is the "marginal" movement as it has a gross rate savings of $3.50 per ton and incurs total systemic delay costs of $3.50 per ton ($2.00 at Lock 1 and $1.50 at Lock 2) and hence receives zero net benefits per ton. The total net transportation benefits are then $2.00 in this example.

To find the incremental benefits attributable to a change in the system (for example an increase in the capacity of Lock 1) one only need compute the resulting new systemic equilibrium attained and compare net transportation benefits. System wide changes caused by altering the characteristics of a component of the system are explicitly accounted for in the new systemic equilibrium.

The actual algorithm used to evaluate potential changes in lock capacities and operating characteristics in the Upper Mississippi River System is a computer implemented extension of that just demonstrated in the two lock example. The thirty-four locks in the system are modeled using the capacities and tonnage-delay relationships explained in

FIGURE 5A
LOCK I

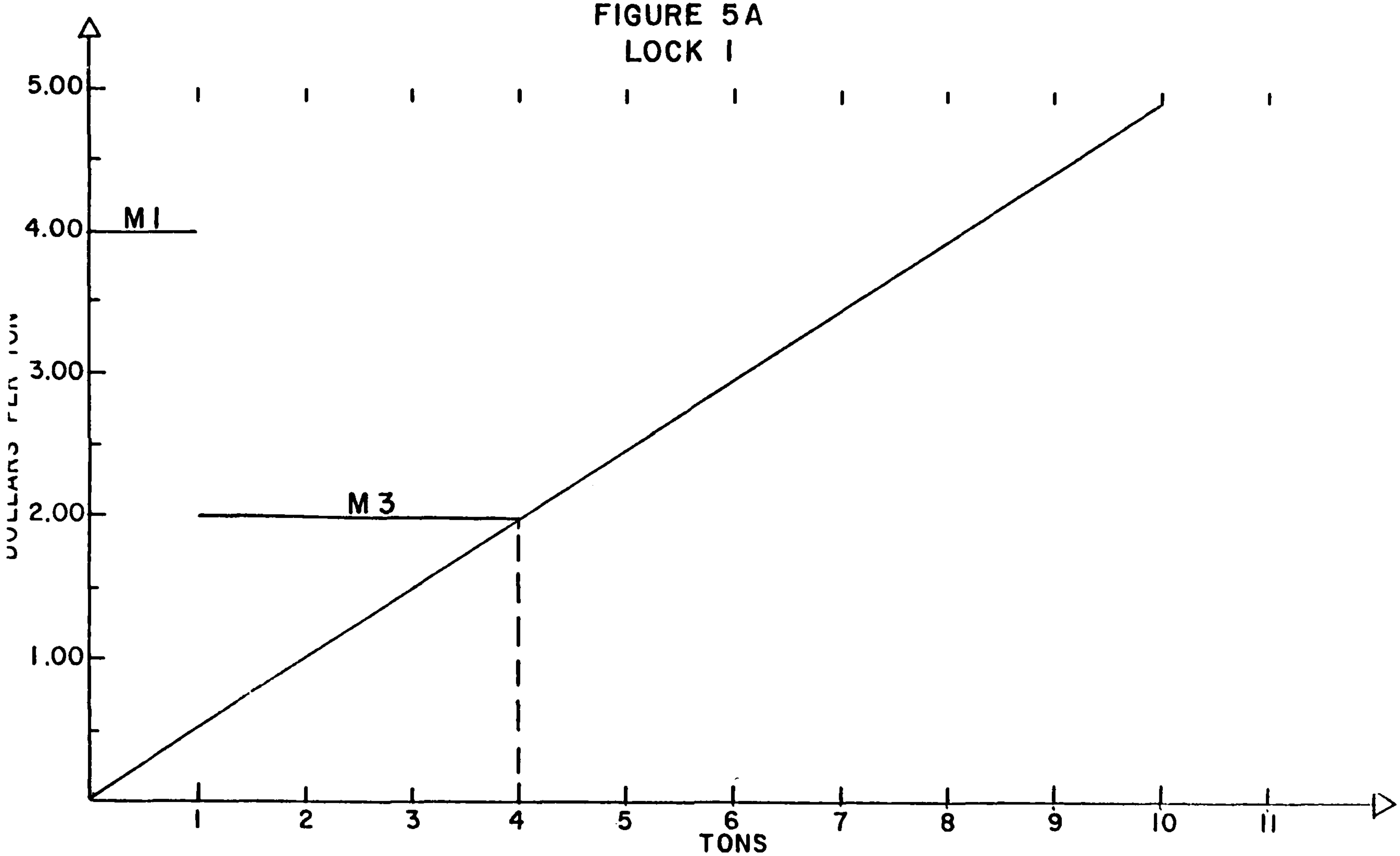
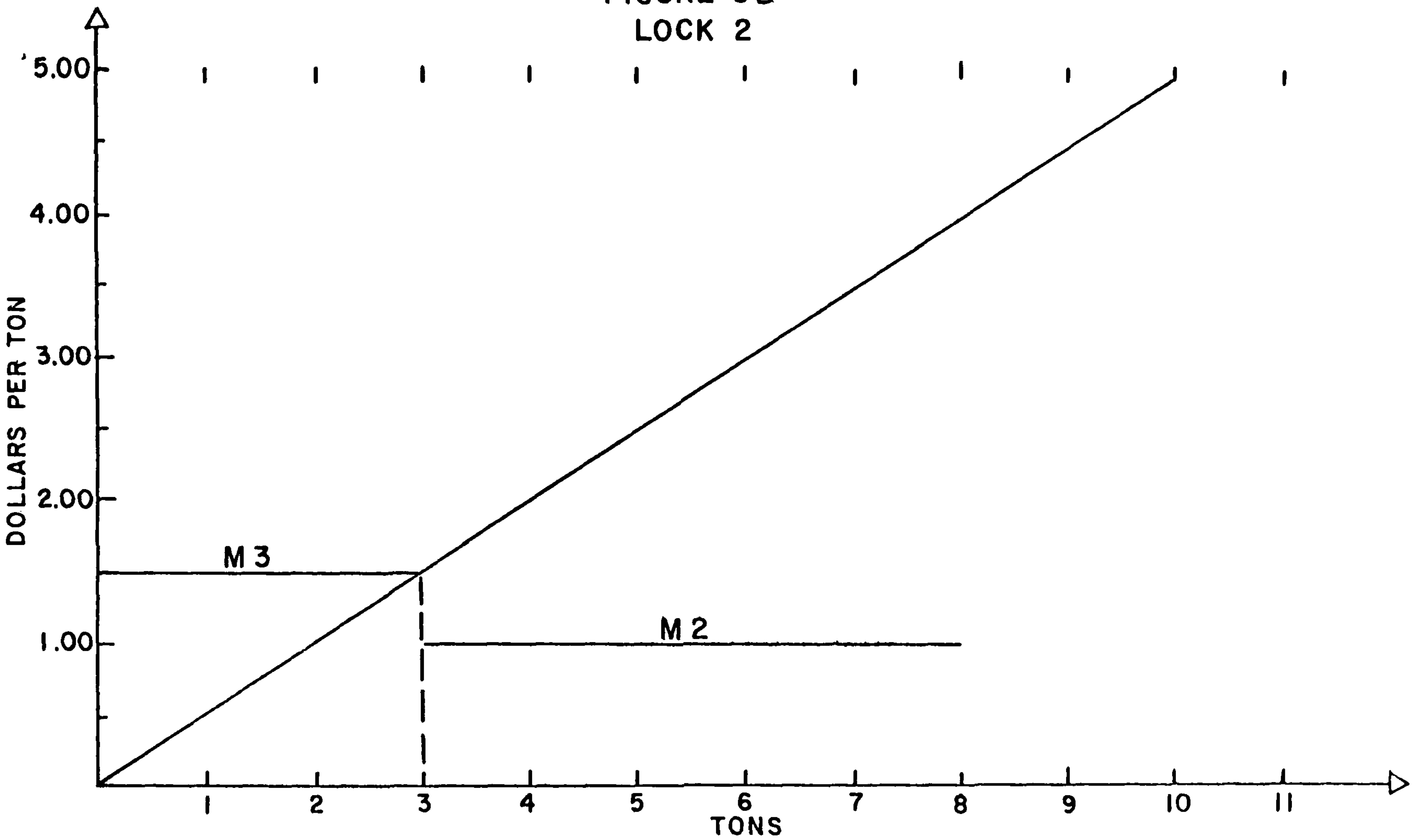


FIGURE 5B
LOCK 2



Section 2 of this appendix. Additionally, since many different commodity types move through the system, each having a different lock specific per ton hourly cost of delay, the gross rate savings of each potential movement are converted to the number of hours of delay they represent at each system lock. Consequently, the systemic equilibria estimated by the model are expressed in units of tons and hours of delay. To compute transportation benefits, the hours of delay are reconverted to commodity specific costs using data developed in this section and netted from the gross rate savings of the non-diverted movements. Equilibria are estimated for traffic demands in the years 1990, 1995, 2000, 2005, 2010, 2020, 2030, and 2040. Benefits for intermediate years are then interpolated from the years actually computed to determine average annual net transportation benefits. This procedure was adopted to hold down computer costs as the algorithm in its present computer format is quite expensive to operate. A complete Fortran listing of the basic computer program follows along with relevant input data used in the evaluation of each scenario.

AD P002 634

WATER SUPPLY

Dr. W. R. Summitt, Supervisory Economist
Economic and Social Analysis Branch-Planning Division
Southwestern Division

Water Supply for municipal and industrial uses has been an important program area for the Southwestern Division since the 1940's. This program interest follows the intense local and regional concerns for dependable water supplies, in the southwest (a region which includes high plains and other areas with limited rain fall and many water quality limitations on water sources).

By 1982, the Southwestern Division had developed 63 lakes with about 6.6 million acre-feet of water supply storage and an estimated firm yield of 2,691 million gallons per day. The projects range from over 400,000 acre feet at a large lake to as little as 33 acre feet of storage in one of the smaller lakes.

This program materialized because of broad public support for water supply from Corps lakes and the ability of the Districts in Southwestern Division to properly plan, design, construct operate projects and to execute workable arrangements with local and state interests.

Southwestern Division developed expertise in both Division and District offices and offers central support capability in the Economics Branch of the Planning Division. This provides a single unified effort and methodology to be applied uniformly across district boundaries yet minimize the coordination effort. It also permits an experienced professional staff to be maintained in a technical area where specialized skills are required.

More than 50 water supply studies have been performed by Southwestern Division, for project formulation and evaluation purposes. These studies include new project water needs, urban studies water needs, and possible reallocation storages at existing lakes for water supply purposes. To properly evaluate water supplies and demands requires appropriate methodologies and techniques to fully assess future water demands. Outlines of three major aspects needed in an assessment of water demands include (1) Water Use Forecasting, (2) Water Conservation, and (3) Price Elasticity of Demand.

WATER USE FORECASTING
Outline

A. Obtain base data

<u>Primary sources</u>

1. Water use by type user (sector, where available)

2. Any historic water use

3. If gross water use only, get estimated use by sector

<u>Secondary sources</u>

1. productivity values

2. recirculation rates

3. current use rates

B. Select forecasting methodology

1. Extrapolate, based on historical

   total

2. Use statistical technique

3. Perform by sector, & sum to total

4. Combination of above

C. Forecasting Water Use

1. By sector (include WC efforts already in use)
   Municipal, Commercial, Industrial, & Other

2. By sector (with additional WC efforts)

D. SWD Forecasting Methodology

1. Municipal = population X use rates.

2. Industrial = employees X use rate x productivity x recirculation.

3. Power = provided by FERC to year 2000

A complicating factor in forecasting M use for a large area is need to compare water demands with water supplies by water producing or water supplying entity (city, town, RWD, etc).

E. Advisable to minimize forecasts, for example:

	50	cities	
	4	sectors	
	200	forecasts	w/o added WC
inside	= 200	"	w added WC-low flow shower
	200	"	w added WC-low flush toilets
	200	"	w added WC- aerators on faucets
outside			
	200	"	w added WC effort
	1000		
plus	?	industrial	
plus	?	power	

WATER CONSERVATION ANALYSIS
Outline

A. Water Conservation (WC)

1. Under Principles & Standards - WC includes actions to:

   (a) reduce the demand for water

   (b) improve efficiency in water use and reduce losses and waste,

   (c) improve land management practices to conserve water.

   " The term does not encompass any storage facilities for the development of new water supplies."

2. Under Principles & Guidelines

   same as P & S ? Yes... practically so.

   different from P & S ? adds (d) Increase the Supply...

3. Corps W/S W/C Procedures Manual, 4/80 IWR WC defined as " any beneficial reduction in water use or water losses."

   WC includes:

   (a) achieving reductions in water use,

   (b) achieving more efficient use of existing supplies,

   (c) providing new supplies.

B. WC Measures (Manual Table 3-1)

1. Types - regulatory practices

   - management practices

   - educational efforts

2. Potential Problem in Evaluating WC Effects

- Some WC efforts readily measurable
- Some WC efforts not readily measurable
  (educational, mang't, & regulatory)

C. SWD Efforts of Evaluating WC

1. Type of Users

   a. municipal - WC efforts inside & outside residential uses,

   b. industrial - WC " in the form of recirculation of water.

   c. power - no special WC efforts noted.

2. Municipal

   a. inside - assume 3 additional WC efforts of low-flush toilets, low-flow shower heads, & aerators on faucets.

   b. outside - assume some reasonable reduction in outside or seasonal water reduction in outside or seasonal water use (10-20%) without adversely affecting physical or esthetic appeal of lawns, shrubs, etc.

3. Compare with versus without uses

   a. baseline uses (without additional WC efforts)

   b. Uses with additional WC efforts

D. Which W/C efforts are to be evaluated? Who decides?

1. Locals - identify those currently used and those likely additional ones

2. If locals <u>do not</u> identify, evaluate potential reductions of some practical additional WC efforts.

E. Report & Display Procedure

a. Compare water supplies versus baseline water uses

b. Compare water supplies versus uses with added WC efforts

c. Display tables of M & I water

- Average day use and Capacity

- Maximum day use and Capacity

In conclusion, SWD has included water supply in many projects since the late 1940s. The policy for proper evaluations has changed significantly since begun, including Principles and Standards, and presently the March 22, 1982 Principles and Guidelines. SWD's capability to accept and apply new policy and work with other entities has been demonstrated through the years.

Water Supply Price Elasticity

Outline

A. Introduction

1. Define " elasticity " = "sensitivity to price change."

2. Why this concept important ? Because if we raise the price enough... demand (Q taken) will decrease.

   It has been identified as a way to reduce the demand for water.

B. Concept of Elasticity

1. elasticity is the ratio of the relative change in the quantity demanded to the relative change in price.

2. types of elasticity - price, income, cross, etc (point, arc)

   - demand and supply

3. degrees of elasticity: elastic-unitary-inelastic

Elastici . must be distinguished from the slope of the line.

The formula for:

$$\text{slope} = \frac{\Delta P}{\Delta Q}$$

$$\text{elasticity} = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

C. Previous & Present Efforts

1. Theoretical - Demand curve can be derived

   - Elasticity can be calculated

   - Procedures Manual indicates it will be used

2. Practical

   a. Full demand curve for water not known

   b. Do not have true market conditions prevailing

   c. Pricing water usually ... to cover costs

   d. Elasticity of demand for water can be calculated

   e. Do not know where the point is on the D Curve.

   f. Therefore, we use surrogate data

      - time series

      - cross sectional

      - other

D. Problem Related to Use of Price Elasticity for Water

1. Inadequate data

   a. no change in Price and Quantity recently

   b. no full Demand curve is known

2. If D curve unknown and Elasticity calculated, then as a practical matter... don't know where point on D curve is

3. Actual basis for pricing water is uncertain

   a. frequently not directly related to cost (esp. MC)

   b. usually related to variable costs

c. sometimes water is a revenue generator

d. price should be such as to cover all costs

e. If greater quantity of water is required because of new customers... who should pay?

4. Variable charges to different users

   a. larger users get lower unit cost

   b. inside city lower than outside city limits

   c. type of customer (residential, commercial, industrial)

   d. size of meter

   e. seasonal rates versus non-seasonal

5. Use of surrogates not fully satisfactory

   a. cross sectional (at one point in time)

   b. time series (coverage through time)

   c. other (inside vs outside users)

6. When Price is changed .. Is reaction a SR or LR response?

E. Conclusions

1. Demand for water is negatively sloped.

2. Price elasticity of D for water is generally inelastic.

3. Price elasticity of D for water varies from place to place, & use to use.

4. Frequently data are not available to know full D curve.

5. To date...surrogates provide our best estimates of price elasticity of D for water.

TABLE 36

PRICE ELASTICITIES

Demand Section	Elasticity	Source
Residential	-0.225	1
Domestic	-0.26	2
Sprinkling (West)	-0.703	1
Average Day	-0.3953	2
Maximum Day	-0.388	1
Commercial-Industrial	-0.10	3
Government	-0.25	4

Source: 1. Howe and Linaweaver, 1967.

2. Burns et al, 1975

3. Hanke and Davis, 1974

4. Roussos and Flack, 1977

Source: U.S. Dept. of Commerce
Office of Water Research & Technology

"Achieving Urban Water Conservation. A Handbook" Sept 77

Water Supply/Conservation Pertinent References

1. U.S. Army Corps of Engineers, Institute for Water Resources.

   a. April 79- An Annotated Bibliography on Water Conservation.

   b. April 79- The Role of Conservation in Water Supply Planning.

   c. April 80- The Evaluation of Water Conservation for Municipal and Industrial Water Supply, Procedures Manual.

   d. Feb 81- The Evaluation of Water Conservation for Municipal and Industrial Water Supply, Illustrative Examples.

   e. May 81- An Annotated Bibliography on Techniques of Forecasting Demand for Water.

   f. May 81- An Assessment of Municipal and Industrial Water Use Forecasting Approaches.

   g. May 81- Selected Works in Water Supply, Water Conservation and Water Quality Planning.

   h. Sept 81- Water Supply/Conservation, Proceedings of the Environmental Advisory Board.

   i. Jan 82- Analytical Bibliography for Water Supply and Conservation Techniques.

2. U.S. Dept of Commerce, National Bureau of Standards.

   April 81- Proceedings of the National Water Conservation Conference on Publicly Supplied Potable Water.

3. U.S. Dept of Commerce

   Sept 77 - Achieving Urban Water Conservation, a Handbook.

   Sept 75 - Proceedings of Conference on Water Conservation and Sewage flow Reduction with Water-Saving Devices.

   Oct 73 - Suburban America: Population Dynamics as Related to Water Resources Planning.

Dec 71 - Pricing and Efficiency in Water Resource Mgt.

Nov 71 - Forecasting Water Demands.

July 71 - Improvement of State Water Right Records.

4. State of California

Mar 77 - Proceedings of Governor's Drought Conference.

5. U.S. Water Resources Council

Jan 80 - The Inventory of Federal Assistance Programs for Urban Supply Systems.

6. U.S. Environmental Protection Agency

Nov 78 - Proceedings, National Conference on Water Conservation and Municipal Waste water Flow Reduction.

July 75 - Systems Analysis for Wastewater Reuse, A methodology for Municipal Water Supply Planning in Water-Short Metorpolitan Areas, Vols I & II.

Feb 74 - Renovation of Secondary Effluent for Reuse as a Water Resource.

7. Board of Engineers for Rivers and Harbors

April 81 - Water Supply Conservation: A Study Manager's Viewpoint.

8. U.S. Water Resources Council

Dec 79 - Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C); Final Rule.

9. Office Chief of Engineers

Feb 82 - Planning Guidance Notebook, Chap 7, Water Supply.

10. U.S. Water Resources Council

March 82 - New Principles and Guidlines, Part V

11. Land Economics

Feb 79 - Urban Residential Demand for Water in the U.S.

AD P002635

WATER SUPPLY/CONSERVATION PLANNING AIDS[1]

by

James E. Crews[2]

INTRODUCTION

The objective of Corps participation in the area of municipal and industrial (M & I) water supply is to insure a reliable supply of fresh water, adequate in quantity and quality for urban and rural needs. National policy, as defined by the Congress, has been evolving over a number of years and is still being clarified and expanded by legislation. This policy recognizes a significant Federal interest in the long-range management of supplies, but assigns the financial burden to the users.

Like Federal policy, water supply and water conservation planning techniques and tools have been evolving over the years. From initial simple predictions of supply and demand, the task of determining deficits and evaluating project proposals now involve complex procedures, many of which have been computerized. The maturation of aids for Corps planners has helped to develop the history of Corps involvment in water supply and water conservation planning. The more important techniques and tools will be discussed, emphasizing their applications.

CORPS WATER SUPPLY PLANNING HISTORY

Water Supply Act of 1958

Prior to 1958, storage for M & I water supply in Corps projects was authorized on the basis of individual project proposals. With the enactment of the Water Supply Act of 1958, a period of joint-venture development of water supply at multi-purpose reservoirs by Federal and non-Federal interests was introduced. The 1958 Act carefully avoided a shift of responsibility for water supply costs from non-Federal interests to Federal interests.

----

[1] Presented at COE Economic and Social Analysis Workshop in St. Louis, MO., Sept. 1982

[2] Sr. Civil Engineer, Institute for Water Resources, U.S. Army Corps of Engineers, Ft. Belvoir, VA. 22060

During these early years in the development of water supply projects, available tools and techniques centered on the hydrologic or supply side of the equation. The demand side was essentially the concept of "demand = population * a constant water use rate".

NEWS, 1965

In 1965, Public Law 89-298 authorized a Federal and non-Federal cooperative study [the Northeastern United States Water Supply (NEWS) Study] to prepare plans to meet the long-range water needs of the Northeast. The legislation also authorized Federal construction and operation and maintenance of certain major single purpose water supply facilities that previously would have been the responsibility of non-Federal interests; however, the appropriate Federal role in implementing the recommendations of that study has yet to be established. The Corps policy recommendation was to use the 1958 Act cost-sharing formula but to allow single purpose reservoir construction.

The NEWS Study was one of the first studies to treat supply management and demand management on an equal basis. The NEWS Study also looked at the disaggregation of water useage to analyze future water demands. This work lead the way for the logical shift from predicting (guessing) future demands to forecasting (explaining) future demands.

Urban Studies Program

In the early 1970's, the Corps inaugurated the "urban studies program". This program looked at the combined water problems of major metropolitan areas and revealed that by and large the complex governmental structures of these areas and the interregional competition for resources precluded optimal development, use, and management of water resources.

One of the more important water supply planning aids to come out of the urban studies program was the development of a computer program called MAPS (Methodology for Areawide Planning Studies). MAPS is a multi-purpose program which can be used for preliminary design, cost estimating, simulation, and economic analysis.

New Era

In 1977, the Carter Administration prompted a shift in Federal water resources planning which emphasized water conservation. The Deputy Assistant Secretary of the Army (Civil Works) set forth an Army policy for the incorporation of a water conservation clause in Federal water supply contracts. This clause required the approval of a non-Federal water management plan prior to purchasing storage in a Federal reservoir. (The Reagan Administration later rescinded this polic)y.

In response to then recent droughts and the Administration's

emphasis on water conservation, the Corps initiated efforts to integrate water conservation into its activities. These efforts have led to the development and publication of new tools for water supply/conservation planning; namely, a procedures manual for evaluating water conservation measures, better techniques for forecasting water demands, and handbooks illustrating the applications of these aids.

Section 22 of Public Law 93-251, 1974, authorized the Planning Assistance to States Program wherein the Corps may cooperate with any state in preparing comprehensive plans for drainage basins in the state. Today, in many states, the Section 22 Program is focusing on water supply and conservation, including leak detection in distribution systems, determination of water supply deficiencies, development of estimates for system repair and rehabilitation, analysis of delivery system adequacy and safety, and estimation of benefits and costs of demand reduction programs.

The Corps is also involved in implementing projects to control natural salts and salinity intrusion in rivers and estuaries; conducting a study of the depletion of the Ogallala aquifer; providing emergency water supplies when drinking water contamination threatens public health or when drought threatens the lives of humans and livestock; and preparing drought contingency plans for Corps reservoirs.

These programs have influenced the direction of new Corps of Engineers water supply/conservation research and has helped to implement a new R & D subprogram devoted to water supply and conservation planning.

In summary, with regard to municipal and industrial water supply, the Federal Government has had a historical role in reservoir construction, technical and financial assistance, and emergency preparation and response. In all of these, the Corps of Engineers has played a significant role and has developed the techniques and tools to plan and manage America's future water resources.

SPECIFIC WATER SUPPLY/CONSERVATION PLANNING AIDS

As can be seen from the generalized flow chart of Figure 1, there are numerous ways of analyzing water resource problems (Shahane, 1976). The first level represents the type of water system; the second stage, the factors affecting the systems; the third stage decides the mathematical function; the fourth step relates to the analytical techniques involved in the analysis; at the fifth level, a specific goal is reached; and in the final stage, the results are achieved.

Many types of mathematical relationships, concepts, and models

have been developed over the years dealing with M & I water supply in the areas of economics, water quality, hydrology, hydraulics, social science, and policy. Most of these, however, are developed independently and usually in responce to specific water resource problems and, in turn, need an adequate understanding of the isolated events that required their development. A number of reports have been published in which comparisons have been made of various computer programs. Of special interest are the following:

1. "Critical Review of Currently Available Water Quality Models", by P.S. Lombardo.
2. "Models and Methods Applicable to Corps of Engineers Urban Studies", by J.W. Brown, M.R. Walsh, R.M. McCarley, A.J. Green, Jr., and H.W. West.
3. "Interdisciplinary Models of Water Systems", by A.S. Shahane.
4. "Computer Programs in Water Resources", by C.S. Chu and C. E. Bowers.
5. "HEC Models for Water Resources System Simulation: Theory and Experience", by A.D. Feldman.
6. "An Assessment of Municipal and Industrial Water Use Forecasting Approaches", by J.J. Boland, D.D. Baumann, and B. Dziegielewski.

Relying upon these reports and other Corps publications, the more important planning aids will be discussed; namely, HEC-5, Water Balance Guide Manual, MAPS, MAIN III System, and Water Conservation Procedures Manual.

HEC-5

The HEC-5 program was designed to simulate the operation of multi-purpose, multi-reservoir systems represented in a river network. Practically any demand for water from a reservoir system can be simulated including flood control, water supply to municipal, industrial and/or agricultural users, hydropower, and instream flow maintenance for water quality. The program classifies these water uses into two general categories: flood control and conservation. Conservation use refers to all non flood control uses. The simulation may be performed using one-hour or larger time intervals. Streamflows must be provided to the model. The program then operates the system of reservoirs to best meet the specific flood control and conservation requirements.

The HEC-5 program may be used to determine both reservoir storage requirements and operational strategies for any water control needs. The performance can be measured in terms of violations of flow limitations or resultant expected annual flood damage and net benefits. A similiar procedure can be used for water supply, however, benefit calculations are currently limited to flood control and hydropower. Individual reservoir storage for water supply demands can be optimized automatically by the program to

determine the required storage to meet a specified demand or the maximum reservoir yield that can be obtained from a specified storage.

The reallocation of user storage in existing reservoirs is another multi-purpose application of HEC-5.

The HEC-5 program has proven to be an effective planning tool which can simulate the operation of 10 reservoirs, 15 control points, 11 diversions. and 5 hydropower plants. For more information the reader is referred to Feldman, 1981 or the HEC-5 programmers manual (HEC, 1979).

Water Balance Guide Manual

In 1980 HEC prepared a water balance guide manual to assist planners in the preparation of water supply use studies. A water balance identifies and quantifies the sources and uses of water in a geographic region for a specified period of time. Such an understanding of the magnitude, location, and availability of water over time is useful in identifying supply and use problems, in assessing their severity, and in examining the supply potential of a region.

Preparation of a balance provides as opportunity to assess data availability and accuracy, and if the data are inadequate, to pin-point where improvements can be made. In addition, knowledge of supply and use as provided through a water balance can assist in identifing opportunities for water conservation and their impact not only upon demand but upon other parts of the hydrologic system; a change in one part (reduced infiltration) may produce a change elsewhere (reduced groundwater recharge).

The guide manual presents: a definition of a water balance; examples of some of its uses; descriptions of the components; a general procedure for computation; specific guidance on collecting supply and use data, and on using methods which estimate components where data are not available; examples showing how water balance data can be presented; and information on the cost, time, and personnel required for preparing a water balance (Hayes, et al, 1980).

MAPS

To assist planners in producing a comprehensive array of alternatives without sacrificing detail or incurring large costs, WES developed the MAPS program. MAPS is a set of computer-based models which perform water balance calculations and develop planning level design and cost estimates. It can be used to identify problems and measures, and then select the least cost facilities to make up these measures. By computerizing the cost, design, and flow balance computations, MAPS can save the planner a great deal of work while allowing him to investigate a very large number of alternatives.

The principal role of MAPS in water supply studies is in the preliminary design and cost estimating of the facilities that commonly appear in a water supply plan; namely, gravity and force mains, pumping stations, open channels, tunnels, water treatment plants, reservoirs, storage tanks, and well fields. In addition to the preliminary design modules in MAPS, the program contains a water distribution analysis program for studying complex piping networks, and modules that simulate the water balance for streams, reservoirs, pipelines, and service area systems. The program also contains modules to perform an economic analysis of a time stream of benefits and costs, and a report generator to prepare summary tables of costs, water use, or population projections for a study. Efforts are under way to add modules for analyzing water conservation. The input to the program is the type of information usually available during the latter stages of a study.

The MAPS program has had extensive use in helping analyze alternative water supply solutions for various Corps districts. Verification studies have been performed on the program and independently checked by others and, with a few exceptions, has been found to be sufficiently accurate for planning studies. (Walski, 1980, OCE, 1980).

MAIN III System

The MAIN III System is a flexible and comprehensive planning tool for estimating and forecasting municipal water requirements. Water requirements are estimated separately for the residential, commerical/institutional, industrial, and public/unaccounted sectors of the community. Within these sectors, requirements are further estimated for individual categories of water uses, such as metered-sewer residences, flat-rate-sewered residences, commerical establishments, institutions, three-digit standard industrial classification manufacturing categories, etc. Estimates are made of mean annual, maximum day, and peak hour requirements.

The MAIN III System may be used to simultaneously project water requirements for up to 24 separate years in addition to the base year. Projections of water usage can be done in three distinct ways or in combination: projection by internal growth models; projection by extrapolitan of local historical data; and/or use of projections made external to the system. Obviously, the most important capability of the program is the projection of urban water requirements; however, an estimate of current water use can also be obtained.

The models in the program were developed from data on 83 standard metropolitan statistical areas and have been proven accurate on communities tested. The program has been revised by the Corps and made user-friendly. Efforts are underway to field test the program in existing Corps water supply studies.

Water Conservation Procedures Manual

Water conservation is defined as any beneficial reduction in water use or water losses. To help evaluate water conservation measures and their impact on a communities water requirements, the Corps developed a procedure that permits a consistent and balanced trade-off between water conservation and increments of new supplies.

Figure 2 presents an overview of the general evaluation procedure. Water conservation measures are identified by the measure-specific analysis. These individual measures are then evaluated against alternative water supply plans. Based on this evaluation, water conservation proposals are developed which can be integrated into water supply plans, yielding alternative water supply/conservation plans. Finally the water supply/conservation plans can be tested for compliance with the desired system reliability. This procedure needs field testing. (Crews, 1981, COE, 1980).

NEW TOOLS PLANNED OR BEING DEVELOPED

Under the Corps' water conservation and supply research and development program efforts are being made to provide additional planning aids. Some of these include:

1. A report on hydrologic methods and models for analysis of water supply;
2. A report on the use of flood water for groundwater recharge;
3. A handbook on methods of forecasting municipal and industrial water use;
4. A procedures manual handbook on evaluating water conservation;
5. A report on technology and procedures for conducting groundwater modeling investigations;
6. A procedures manual for conducting conjunctive use studies for water supply;
7. A report on establishing water supply reliability;
8. A report on how to evaluate existing water distribution systems; and
9. Modifications to MAPS.

SUMMARY

The Corps of Engineers has had a long history in the planning for M & I water supply. It is only recently that methods and procedures have been developed that greatly enhance the planning capability of today's water supply planner.

BIBLIOGRAPHY

Chu, Chung Sang and C. Edward Bowers, Computer Programs in Water Resources, Water Resources Research Center, University of Minnesota, WRRC Bulletin 97, November 1977.

Corps of Engineers, An Assessment of Municipal and Industrial Water Use Forecasting Approaches, Institute for Water Resources CR-81-C05, May 1981.

Corps of Engineers, Doing Institutional Analyses, Institute for Water Resources draft contract report, September 1980a.

Corps of Engineers, Guide Manual for Preparation of Water Balances, Hydrologic Engineering Center, November 1980b.

Corps of Engineers, HEC-5 Simulation of Flood Control and Conservation Systems: Programmer's Manual, Hydrologic Engineering Center, 1979.

Corps of Engineers, Interim Guidance on Use of MAPS Computer Program for Water Supply and Conservation Studies, ETL 1110-2-259, April 1980c.

Corps of Engineers, MAPS User's Guide and Documentation, EM 1110-2-502, November 1980d.

Corps of Engineers, Models and Methods Applicable to Corps of Engineers Urban Studies, Waterways Experminent Station, August 1974.

Corps of Engineers, The Evaluation of Water Conservation for Municipal and Industrial Water Supply: Procedures Manual, Institute for Water Resources CR-80-1, April 1980e.

Crews, James E., and Kyle E. Schilling, "A Procedures Manual for Evaluation of Water Conservation Planning," Proceedings, National Water Conservation Conference on Publicly Supplied Potable Water, U.S. Dept. of Commerce, NBS 624, pp 197-206, April 1981.

Feldman, Arlen D., "HEC Models for Water Resources System Simulation: Theory and Experience," Advances in Hydrosciencs, Vol. 12, 1981.

Lombardo, Pio S., and Ranald F. Ott, "Water Quality Simulation and Application," Water Resources Bulletin, Vol. 10 No. 1, pp 1-9, February 1974.

Shahane, A.N., "Interdisciplinary Models of Water Systems," Ecological Modeling, Vol 2, pp 117-145, 1976.

Walski, T.M., "MAPS-A Planning Tool for Corps of Engineers

Regional Water Supply Studies," <u>Water Resources Bulletin</u>. Vol. 16 No. 2, April 1980.

COAL PORT ANALYSIS

BY

FRANK T. WOOTTON, JR., P.E.
Chief, Planning Division

PRESENTATION TO BE GIVEN TO
THE ECONOMIC AND SOCIAL ANALYSIS WORKSHOP

The port of Hampton Roads is strategically located approximately midway on the Atlantic Seaboard.

The area is a rapidly expanding region whose economy has historically depended upon port and related activities. The natural benefits of size, location, and ocean accessibility have been responsible for the substantial commerce enjoyed by the port--one of the most important harbor complexes in the world.

The authorized project currently serving Hampton Roads provides for a channel 45 feet deep and 1,000 feet wide in the lower Chesapeake Bay (Thimble Shoal) to Hampton Roads. In Hampton Roads, channels 45 feet deep with widths of from 800 to 1,500 feet provide access to the Norfolk and Western coal-loading facility in Norfolk and the CSX coal-loading facility in Newport News. Channels of lesser depths are also maintained up the Elizabeth River. Maintenance of the existing channels and anchorages inside Hampton Roads Harbor, including permit dredging, requires the removal of approximately 4 to 5 million cubic yards of dredged material annually.

One major Hampton Roads Port Activity--the export coal business--has been receiving world-wide attention. Because of its fine natural harbor and its proximity to the Appalachian coalfields, Hampton Roads is the nation's largest coal port, handling a majority of the country's exports overseas.

With the tremendous increases in the price of oil in recent years and the apparent uncertainty of its supply, foreign countries are converting to coal as a major energy source. The renewed international interest in coal has resulted in a significant increase in coal exports from the Norfolk and Western coal loading facility in Norfolk and the CSX coal loading facility in Newport News. In 1977, 26.6 million tons of coal moved through the port, while in 1980, 50.1 million tons of coal were shipped from Hampton Roads. According to the Virginia Port Authority, almost 50 million tons of coal were shipped from Hampton Roads in calendar year 1981 even though coal movements were hampered by an extended coal miner's strike. During the first eight months of 1982, 38.5 million tons of coal have moved through Hampton Roads, and the Virginia Port Authority anticipates over 50 million tons by the end of the year. In fact, there is a chance that this may be a record year.

Once coal reaches Hampton Roads, it is stored in the cars which transported it from the mines. Each car is classified according to its particular type of coal, which allows control over how much of each type of coal is mixed during loading operations to obtain the required blend. It is interesting to see how the coal is actually loaded on the vessels. The coal cars are positioned in rotary dumpers which turn the cars completely over so that the coal falls into transfer bins below the dumpers. From the transfer bins, the coal is fed onto large conveyor belts, transported to the loading tower, and deposited in the vessel.

As a result of the increase in demand for coal, several plans have been announced for constructing additional coal loading facilities in Hampton Roads. The A.T. Massey Coal Company, Inc., of Richmond

is remodeling an inactive ore pier at Newport News. This third Hampton Roads coal pier should be in business by the spring of 1983 to handle up to 12 million tons annually.

In 1980 Cox Enterprises, Inc., of Atlanta announced plans to build a coal pier on a 350-acre Portsmouth site. However, since that time Cox Enterprises and the Norfolk and Western Railway Company have been engaged in a legal dispute over land ownership, postponing plans for the pier indefinitely. Recognizing the immediate need for additional coal facilities in Hampton Roads and the scarcity of suitable land sites, Virginia's Governor Dalton proposed a bill that would authorize the Virginia Port Authority to condemn the Portsmouth site for a state-owned coal loading terminal. The legislation was approved by the General Assembly in April 1981. Originally, the proposed state-owned pier was expected to handle 27 million tons of coal a year. However, as a result of feasibility studies consideration is now being given to reducing the annual throughput to about 18 million tons.

More recently, Dominion Terminal Associates has announced plans for the construction of another coal loading facility in Newport News near the Massey terminal and the CSX facilities. This facility will have a throughput capacity of 15 million tons per year.

Finally, plans have been announced for coal terminals at Pinners Point in Portsmouth and on the 35-foot deep channel on the Southern Branch of Elizabeth River in Chesapeake, Virginia. Each of these facilities are smaller scale and would be capable of handling 3 to 5 million tons annually. The feasibility of these small scale facilities is still questionable since the larger facilities will be ample for predicted increases in the demand for coal.

Hampton Roads is making progress toward meeting the world's increasing demand for coal. But, with or without the additional coal loading facilities, there are problems which jeopardize the position of Hampton Roads as a major coal exporter.

One problem which faces most U.S. ports is that the channels are not deep enough to accommodate the increasing vessel sizes. The trend to build large "super" vessels has been overwhelming and has caught the United States ports unprepared. Currently, east and gulf coast ports are limited to fully loaded vessels in a range of 40,000 to 80,000 deadweight tons drawing 45 feet. Hampton Roads coal terminals receive colliers in excess of 100,000 deadweight tons, but these vessels cannot sail fully loaded due to draft limitations of the existing channels.

On 2 February 1981, the Virginia Pilot Association checked the drafts of vessels at anchor and found that there were 67 vessels which could not load coal to maximum capacity. Coal transported from the east coast to Europe in a 120,000 deadweight ton vessel costs about $6.00 per ton less than in a smaller 60,000 deadweight ton vessel. Therefore, existing channel limitations have an adverse impact on the United States competitive position in the world coal export market.

The capacity of a port to receive large coal colliers, load, and turn them around without excessive delays has a major bearing on the competitiveness of coal on overseas markets. Vessel delays, for whatever reason, are costly. Before the coal miners' strike last year, it was not uncommon for the queue of coal colliers awaiting pier space in Hampton Roads to exceed 150 vessels. It is estimated that each day a collier waits costs an average of $15,000; some colliers have anchored for several months. These delays translate into increased waterborne transport costs to ship coal overseas.

The solution involves a need for deeper channels to accommodate super coal colliers, commensurate docking and berthing facilities to permit quick loading and release of vessels, and a smoothly operational interface between the carriers and coal interests. The port has already made considerable progress toward reducing excessive vessel delays with the proposals for new coal loading facilities and improved coordination between carriers and coal interests.

Also, to help answer the port's needs, the Norfolk District has responded to Virginia's request by completing a Congressionally authorized study on the advisability of deepening these channels serving Hampton Roads.

At this point, I would like to discuss in some detail the nature of our economic studies for establishing the feasibility of channel deepening in Hampton Roads.

The monetary benefits for the deepening project were based entirely on waterborne transportation savings. In other words, deeper channels allow larger vessels to transport coal at lower unit prices.

The quantification of the annual waterborne transportation savings which would accrue from an improved channel depth required a detailed analysis of commodities, trade routes, and vessel fleet distribution.

Our analysis showed that coal is the principal commodity which would benefit from deeper channels in Hampton Roads, and that coal from Hampton Roads is transported to three principal areas: Europe, Japan, and South America.

In developing coal projections for Hampton Roads, we used a study by Robert R. Nathan Associates, Incorporated entitled "U.S. Deepwater Port Studies, Commodity Studies and Projections." This report was prepared for the Institute of Water Resources in 1972, and at the time of our feasibility studies provided the most complete look at future coal movements from the United States. We also looked at historical trends and other available sources for coal projections. Based primarily on the Nathan study, we estimated total coal exports from Hampton Roads to reach 50 million tons in 1990 (base year) and remain constant over the life of the project. As indicated by the slide, Hampton Roads coal exports have already reached 50 million tons. It is significant to note that the amount of coal exports was estimated to be the same with and without any channel improvement.

In addition to commodity projections, we had to look at the world fleet and establish what the vessel size distribution would be for a given channel depth. More specifically, vessel size distributions were predicted for 1990 (base year), 2000, and 2040 based on careful consideration of the following factors:

Trends in the world fleet.

Trends in Hampton Roads traffic.

Port constraints.

Trade routes.

Prospective tonnage.

Economics of large vessels.

The following slides show the predicted vessel size distribution for Hampton Roads coal movements to Europe in 1990 (base year) for the existing 45-foot channel and an improved 55-foot channel depth.

Having established trade routes, coal export projections, and vessel fleet projections, and utilizing vessel cost data provided periodically by the Corps Water Resources Support Center, we computed annual waterborne transportation savings.

To illustrate the method and for the sake of simplicity, lets consider just two vessel sizes--60,000 deadweight tons and 120,000 deadweight tons. As shown on the following slide, there would be a savings of $6.00/ton using a 120,000 dwt vessel on an improved 55-foot channel instead of a 60,000 dwt vessel on the existing 45-foot channel. Since the estimated tonnage would be the same with or without the project, this unit saving was then multiplied by the annual tonnage to obtain the annual savings.

Of course, the complete analysis involved studying the complete fleet distribution and computing the total average annual waterborne transportation savings for various incremental channel depths. In computing average annual savings, we considered the project life to be from 1990 to 2040. The annual benefits and corresponding annual costs were then compared for each increment to determine what depth provided the most net annual savings (Subtracting the annual costs from the annual benefits gives you the net annual benefits.) The results of our economic analysis indicated that net annual savings maximized at a depth of 55 feet.

The following slide provides an economic summary of the recommended 55-foot portion of our project for Hampton Roads.

The estimated first cost (or construction cost) of this project is approximately $421,700,000, based on October 1981 price levels.

The benefit to cost ratio for the Norfolk Harbor 55-foot Deepening Project was estimated to be 3.6 to 1. The 3.6 to 1 benefit-cost ratio was based on metallurgical coal and did not include the recent development of the world-wide steam coal market. With the potential developments which I previously mentioned, the port will have the capacity to handle greater quantities of steam coal. As port developments occur, the benefit-cost ratio will change. But, in order to give you a point of reference, consider this--if an additional 40 million tons of steam coal could be handled through Hampton Roads annually , then the benefit-cost ratio would become about 6.0 to 1.

Our studies show that with every foot of increased draft, the typical using collier would be able to load another 5,000 tons of coal. If channels in Hampton Roads are deepened to 55 feet, some of the deeper draft vessels could carry an additional 50,000 tons per collier. In the past it has been estimated that the movement of each additional ton of export coal would reportedly bring another $18.42 to the state economy.

The 55-foot deep channel project would include the following:

a. A new Atlantic Ocean Channel would be dredged off Cape Henry, 1,000 feet wide and approximately 11 miles long. This channel would actually be dredged to 57 feet to compensate for greater wave action in the open ocean. Since natural depths in this area are about 50 feet, no dredging has previously been required for our existing 45-foot project.

b. The depth of Thimble Shoal Channel would be increased from 45 feet to 55 feet below mean low water over its existing 1,000-foot width. This channel would be about 13 miles long and include adequate protection for the Thimble Shoal Channel Tunnel.

c. The depth of the Channel to Newport News would be increased from 45 feet to 55 feet below mean low water over its existing 800-foot width to the coal terminal at Newport News, a distance of about 5 miles.

d. The depth of Norfolk Harbor Channel would be increased from 45 feet to 55 feet below mean low water over its existing 800- to 1,500 foot widths to the coal terminal in Norfolk at Lamberts Point, a distance of 9 miles.

e. Three fixed mooring anchorage facilities would be constructed, each capable of accommodating two large vessels simultaneously. Depths of the anchorages would be 55 feet below mean low water. The concept of fixed mooring anchorages is new to Hampton Roads. Currently, vessels anchor in the free floating position. Because of tide and wind fluctuations, this method of anchoring requires a large circular area for one single vessel. During the feasibility study, consideration was given to providing additional circular anchorages. However, the recommended fixed mooring concept is a much more feasible plan from both an economic and environmental standpoint. With the fixed mooring concept, six vessels can be anchored in an area which could accommodate only one large vessel in the free floating position. Thus, the fixed mooring facility involves less dredged material to be removed and accommodated at a much lower cost.

The Board of Engineers for Rivers and Harbors, one of our primary review echelons, has recommended that the channel deepening be accomplished with disposal of all suitable material in the ocean. All unsuitable material would be taken to Craney Island Disposal Area. Craney Island, located in the heart of the dredging activity. has served as a valuable confined disposal area since 1955. It is approximately 2,500 acres in size and already contains more than 140,000,000 cubic yards of dredged material. Through intensive management of the site, it should continue to serve as a disposal area well into the next century.

What is the status of the Feasibility Report? Well, the report and all related documents have been reviewed by Mr. William R. Gianelli, Assistant Secretary of the Army for Civil Works. The Secretary's letter report is being coordinated with the Office of Management and Budget prior to transmitting the reports and pertinent documents to Congress.

Due to the urgency and national importance of this project, $2.6 million was included in the President's Fiscal Year 1982 budget for Continuation of Planning and Engineering studies and an additional $3.3 million has been included in his proposed budget for Fiscal Year 1983. Continuation of Planning and Engineering is a new but important study category to the Norfolk District. Its biggest advantage is that it allows preconstruction investigations prior to Congressional Authorization of the project as recommended in the feasibility stage. Thus, by eliminating the normal wait for Congressional Authorization and subsequent funding for Advanced Engineering and Design, Continuation of Planning and Engineering expedites the preconstruction process of this urgent project.

These preconstruction planning studies are necessary before construction can begin. In this stage, detailed engineering and design studies would be conducted. In addition, we would conduct extensive environmental investigations to determine impacts from the proposed deepening. In this regard, the project has recently been model tested using the Chesapeake Bay Model, an actual physical model of the entire Chesapeake Bay system. The results of these model tests will be evaluated and tell us the effects of the deepening on estuarine circulation in Chesapeake Bay, including the effects on salinity and the oysters in the James River.

As we envision it now, emphasis will be placed on completing all detailed environmental and design studies for the 55-foot project over the next 3 years. This would enable us to initiate construction in Fiscal Year 1986. There is, of course, the potential for initiating at least some increment of the project at an earlier date in accordance with possible arrangements involving innovative financing. The Commonwealth and Assistant Secretary of the Army for Civil Works have already discussed these possible arrangements. Under our current plans, the project will probably be constructed in two 5-foot increments--from 45 to 50 feet in Increment 1 and from 50 to 55 feet in Increment 2. Actual

construction time is currently estimated at 3 years for deepening to 50 feet and an additional 4 years to the ultimate 55-foot depth. Hopefully, we can shorten the construction time. Also, it is important to note that in the interest of exporting coal, the outbound lanes on each increment would be dredged initially. This would of course further expedite use of the project.

In concluding, I would like to share with you some of the lessons we learned during this investigation. There were a number of problems which surfaced ranging from disposal of dredged material to the need for extensive environmental studies. However, in keeping with our economic theme, I want to emphasize two problem areas in the development of our economic studies. Specifically, we learned lessons in establishing both coal projections and fleet size distributions.

With regard to coal projections, we found that the world coal market is very complex and the development of reliable projections is beyond the scope of a normal Corps feasibility study. For this reason, I would emphasize to those of you who are or will be conducting a similar study to be aware of this potential problem. It is most important that a comprehensive coal study be available for your study. If this is not the case, consideration must be given to contracting for such a study, which will be quite expensive.

With regard to vessel size distributions, we found that they were just as much a factor in determining waterborne transportation savings as were the coal projections, even though development of our fleet projections were not based on any sophisticated projection techniques. To give you an idea of how sensitive waterborne transporation savings are to the vessel size distribution, consider the impact of shifting 20 percent of say 50 million tons of coal from the 80,000 dwt vessel to the 150,000 dwt. This would result in an increase in annual savings of $40 million. Thus, since navigation projects could be sensitive to not only commodity tonnages but also vessel fleet distributions, emphasis should be placed on sensitivity analyses for both variables.

This concludes my presentation. I would be happy to entertain your questions at this time.

MARINE MANAGEMENT SYSTEMS, INC.

DEEP DRAFT NAVIGAION

I. INTRODUCTION

Data on U. S. flag ships which have been placed into the Marine Management System computerized Economics and Planning System residing on the GE Time-Sharing Network, and now readily accessible for economic analysis.

These costs represent estimates based on first and second quarter 1982 current operating costs. The second hand ship costs are unrefined estimates, and additional input is anticipated during the next month, to refine these numbers. Foreign flag ship construction and operating costs are presently being developed. Certain ships are not included herein because they do not exist in the U.S. fleet; are presently not contemplated for construction; or are not a representative international vessel. These vessels are:

9,000 DWT -	General Cargo
2,400 TEU -	Containership
2,800 TEU -	Containership
3,000 TEU -	Containership
SEABEE -	(There are only 5 Seabees worldwide - 2 USSR, 3 U.S.).
LASH -	(There are 26 over 10,000 DWT, 4 Liberian flag, 1 Dutch flag, 2 German flag, 19 U.S. flag).

The time charter rate is developed for new and second hand vessel costs using the following assumptions:

a) Seventy percent financing for 15 years at 15%.

b) Current operating costs (manning, insurance, provisions, repairs and miscellaneous) at no escalation.

c) Zero taxes.

Additionally, the residual value of a new ship is assumed to be 25% of original cost at the end of 15 years, and the second hand vessel is assumed to have a residual value of 10% of purchase price.

Cost data, ship and voyage characteristics and sample runs are included in Exhibits A, B and C. The data that is now available in the computer is summarized as follows:

II. DEVELOPMENT OF DATA

This report provides data on ship operating costs and characteristics as well as voyage cost and characteristics for both U.S. and foreign flag operations. The data included herein in table form include the following:

1. Ship Costs
   - A. Capital Investment
     - 1) Ship Cost - new and second hand
     - 2) Annual Finance Charges (70% financing at 15% for 15 years)
     - 3) Residual Value (25% on new vessels, 10% on second hand vessels)
   - B. Operating Costs
     - 1) Wages
     - 2) Subsistence
     - 3) Stores & Supplier
     - 4) Maintenance and Repair
     - 5) Insurance
     - 6) Other
   - C. Total Costs
     - 1) Annual Cost (A&B above)
     - 2) Time Charter Equivalent Rate

2. Ship Characteristics
   - A. Deadweight
   - B. Cubic Capacity
   - C. LOA (fleet)
   - D. Beam (fleet)
   - E. Draft (fleet)
   - F. TPI (tons per inch)
   - G. Horsepower
   - H. Speed
   - I. Fuel Consumption (Sea/Port - HVF and Diesel Oil)

3. Voyage Costs

A. Port Charges (Per DWT or Per Container)

B. Fuel Prices (HVF and Diesel Oil)

4. Voyage Characteristics

A. Distance-One-Way

B. Port Days (Loaded port and discharge port by ship type)

C. Draft Limit (Load port and discharge port)

5. Vessel Types

The following vessel types are provided:

Dry Bulk	-	Foreign Flag - 15,000 DWT, 25,000 DWT, 35,000 DWT, 40,000 DWT, 45,000 DWT, 50,000 DWT, 60,000 DWT, 80,000 DWT, 100,000 DWT, 120,000 DWT, 150,000 DWT - U.S. Flag - 25,000 DWT, 80,000 DWT - 13 ships in total
Tanker	-	Foreign Flag - 25,000 DWT, 35,000 DWT, 40,000 DWT, 50,000 DWT, 60,000 DWT, 80,000 DWT, 90,000 DWT, 120,000 DWT, 150,000 DWT, 175,000 DWT - U.S. Flag - same sizes - 20 ships in total
Container Ships	-	Foreign Flag - 600 TEU, 1000 TEU, 1200 TEU, 1400 TEU, 1600 TEU, 2000 TEU, 2400 TEU, 2800 TEU - U.S. Flag - same with exception of 2800 TEU ship which is not included - 15 ships in total
General Cargo	-	Foreign Flag - 11,000 DWT, 14,000 DWT, 16,000 DWT, 20,000 DWT, 24,000 DWT, 30,000 DWT - U.S. Flag same - 12 ships in total

6. Voyage Itineraries

Sixteen hypothetical voyages have been provided, namely:

Trade Type		One-Way Distances
Bulk Voyages	-	1500 mile, 2500 mile, 5000 mile and 10,000 mile

Tanker Voyages - 1500 mile, 2500 mile, 5000 mile and 10,000 mile

Container Voyages - 1500 mile, 2500 mile, 5000 mile and 10,000 mile

General Cargo Voyages - 1500 mile, 2500 mile, 5000 mile and 10,000 mile

The above information is provided in detail in Exhibits A-1 through C-20 appearing at the end of the report.

III. DEVELOPMENT OF BREAKEVEN TIME CHARTER RATES AND TRANSPORTATION COST PER TON RATES

In order to make a ready comparison between marine transportation alternatives, transportation costs are reduced to time charter rates and/or freight rates.

Time Charter Rates - A time charter rate is expressed in terms of dollars per deadweight per month. It represents the rate at which an owner of a vessel will lease the vessel to a shipper for a given period of time. Port charges, canal tolls, cargo handling costs and fuel costs are not included in this rate. The rate reflects only the cost of hiring the vessel. A time charter may be for a single voyage or for a period of six months, one year, five years or longer.

For example, if an 80,000 deadweight vessel is offered at $8.00/DWT/Mo. for a three-year period, the charter would pay $8.00 X 80,000 DWT equals $640,000 per month.

Freight Rates - A freight rate is expressed in terms cost per cargo ton delivered. The freight rate relates to a specific voyage and includes all transportation costs, including port charges, cargo handling and fuel costs. The shipper is not seeking to hire a ship but rather wishes to contract for the transportation of a specific quantity

of cargo on a specific voyage. The shipper is seeking to contract for a single voyage "spot" charter. For example, suppose the shipper wishes to move 50,000 tons of coal from Hampton Roads to Rotterdam. The ship owner quotes $12.00/ton (normally through a broker). Thus, for a fixed price of 50,000 tone X $12.00, the shipper will pay $600,000.

III.1 Development of Time Charter Equivalent Rate

The time charter equivalent rate provides a single number which incorporates the cost of the ship, terms and amount of financing, vessel operating costs (manning), provisions & stores, insurance, maintenance and repair and miscellaneous charges. The time charter equivalent rate has been developed on a breakeven basis and represents the rate a ship owner must get to cover all operating costs and pay off his ship financing.

In order to develop the time charter equivalent rate for each of the selected vessels and operating costs, the Marine Management Systems Time Charter Analysis Program is accessed by the simple command, RUN TIME.

The system permits calculation of breakeven time charter rates by solving for a required 0% rate of return. A ceiling time charter rate of $20.00/DWT/Mo. was input into the programs to avoid excessive run-up of CRU's (Computer Resource Units) in performing calculations. This ceiling, however, is too low for the smaller vessels (i.e., under 80,000 DWT), and therefore, the user of the system merely adds a 0 to the vessel DWT input, and, of course, the resulting T/C rate must be adjusted by moving the decimal one place to the right.

We have included one example of the various cost and cash flow schedules that can be provided by the system following the 25,000 DWT bulk time charter case.

The time charter analysis program, although specifically designed for tanker and dry bulk vessels, can also be used for containerships. The results for containerships is shown as $ per TEU per month. The TEU capacity of the vessel is shown in place of DWT. In order to accommodate containerships, two zeros are added to the TEU equivalents (with the exception of the 600 TEU vessel, where three zeros are added). The results developed are then manually adjusted as shown in the Exhibits.

A quick examination of the time charter equivalent rates shows that the rates go down significantly for larger vessels as well as for foreign flag versus U.S. flag.

III.2 Development of Freight Rates (Transportation Cost Rates)

The freight rate provides the basic unit for comparison of transportation alternatives and is also the specific unit for determining the cost/benefit associated with specific port improvement programs.

Port improvements ultimately provide cost benefits in marine transportation in only two ways, namely:

- increasing the size of vessel that can call on the port
- reducing port turnaround time

There are, of course, additional benefits to the port such as increase in throughput, but this will not impact the cost of transportation unless one or both of the benefits mentioned above are realized.

By developing the transportation cost per ton associated with different size vessels and different port turnaround times, the cost per ton differences associated with these factors can be developed, which when multiplied by the annual throughput at the particular port, will provide the potential savings associated with specific port improvement projects.

In order to develop freight rates (transportation cost) per ton, we need to bring together specific data on ship characteristics, voyage characteristics, voyage costs and ship operating costs. The ship operating costs have already been developed and reduced to a time charter equivalent rate. Ship characteristics, voyage characteristics and voyage costs must be gathered. These are then stored in computerized data files in the MMS Economics & Planning System.

IV. DEVELOPMENT OF COMPUTERIZED DATABASE

A file is created for each ship and voyage. The ship data files are straightforward and self-explanatory with the exception of the container vessels (Ship #'s 300-305). Here the data had to be input in a certain way so that when the data is used, results in terms of TEU's, rather than DWT, can be provided.

Item #5, Summer DWT, represents the number of TEU's multiplied by 10. This number is used to calculate port charges based on the port costs stored in the voyage file. Port costs include stevedoring and cargo handling costs, as well as normal port charges and dues.

Items #9 and #10 are not actual cubics, as is the case for non-container vessels. These cargo cubics are derived values to assure that costs are developed on a TEU, as opposed to DWT basis. The computer programs permit cargo restriction by cubic. Therefore, a stowage factor of 40 is shown in the voyage file and the cubic is derived by multiplying 40 times the TEU capacity of the vessel (i.e., a 600 TEU vessel has for the purpose of calculation 24,000 cubic feet of capacity). The actual vessel DWT is shown in Items #21 (Winter DWT) and #22 (Tropical DWT) of the ship file. The breakeven time charter (Item #29) rate has the decimal moved one place to the left to offset the extra digit added to the number of TEU's. The ship cost shown in each file (Item #18) is based on second hand ship costs, as well as operating and financial costs.

The voyage files are also *self-explanatory*, again with the exception of the container voyages where the stowage factor (Item #32) is used specifically for calculations; and port charges have been adjusted by moving the decimal point to the left to reflect the fact that the number shown for DWT in the containership file represents 10 times the number of actual TEU's on the ship.

The case examples in Exhibit E show how ships, voyages and operating costs can be brought together to provide transportation cost/ton as well as voyage summaries. The key information provided by the analysis shows:

Cargo/Voyage
Days/Voyage
Voyages/Year
Annual Cargo Delivered

Annual Voyage Costs
Annual Charter Costs
Total Costs
Cost/Ton

In the case of the containerships, the resulting transportation cost/ton is, in reality, transportation cost per TEU.

The voyage summary shown for the containership has been modified so as to provide costs on a per TEU basis. The restriction due to vessel cubic and the Summer DWT shown are directed results, so as to arrive at the proper cargo DWT (which, in this case, is the number of TEU's).

SCHEDULE 1

SHIP COST PROFILE

CHARACTERISTICS

Ship Name:
Ship Owner:
Flag:

Speed Loaded: ________
Speed Ballast: ________
Fuel Consumption
HVF Sea____ HVF Port____
D.O. Sea____ D.O. Port____

Ship Type
Delivery Date
Crew:
Nationality and Number Officers
Nationality and Number Crew
Total ________

OPERATING COSTS

A. Annual Wages

	Deck Officers	Engine Officers	Radio Officers	Deck Crew	Engine Crew	Stewards	Other	Total
Basic Wages								
Benefits								
Overtime								
Total Annual Comp.								

Total Crew Costs ________
Other Costs* ________
Total Annual Cost ________

B. Subsistence: ________

C. Stores & Supplies: ________

D. Maintenance and Repair ________
Annual
Special Survey Allowance Total

*Repatriation, Training, etc.

Schedule 1 (Continued)

E. Insurance

Hull & Machinery	________
Protection & Indemnity	________
War Risk	________
Total	________

F. Other Operating Costs*

Total (A through F) ________

G. Ship Construction and Capital Costs

Ship Costs: (if available)

Estimated Original Cost	________
Estimated Current Market	________

H. Financing

	Current	Actual (if available)
Amount of Loan		
Interest Rate (%)		
Term (years)		
Type (level payment)		

I. Depreciation

Type
Years

J. Tax Rate

*Identify

VOYAGE ANALYSIS CALCULATION SHEET (SIMPLIFIED)

VESSEL : ____________________ DATE : ____________________

BALLAST VOYAGE: ____________________ CALC BY: ____________________

LOADED VOYAGE : ____________________

TIME ANALYSIS	DISTANCE	SPEED	CARGO TONS	HANDLING RATE	TOTAL DAYS
BALLAST SEA					
LOADED SEA					
LOAD PORT					
DISCH PORT					
CANAL					
TOTALS					

FUEL CONSUMPTION	CONS LT/DAY	TOTAL DAYS	TOT CONS.	$/LT	FUEL COST
BAL SEA: HVF/BKRC					
DIESEL OIL					
LD SEA: HVF/BKRC					
DIESEL OIL					
PORT: HVF/BKRC					
DIESEL OIL					
CANAL: HVF/BKRC					
DIESEL OIL					
TOTALS					

CARGO CALCULATION TYPE CARGO ____________________

DEADWEIGHT TONS : ____________________

LESS WATER & STORES : ____________________

LESS BUNKERS : ____________________

LESS RESERVE BUNKERS: ____________________ ____________________

CARGO DEADWEIGHT : ____________________

CUBIC CHECK

VESSEL CUBIC (CUFT) ____________________

÷ CARGO STOW FACTOR ____________________

= CDWT CUBIC LIMIT ____________________

REVENUE FIO $

FRT RATE $/TON ________ x CARGO TONS ________ = GROSS FRT $ ________

OR WORLDSCALE

WS RATE $\frac{\_\_\_\_\_\_}{100}$ x WS FLAT: ______ x CARGO TONS ______ =

COMMISSION % ________ x GROSS FRT $ ________ = COMMISSION $ ________

= NET FRT $ ________

VOYAGE COSTS $

CANAL TOLL $: REG TONS ________ x CANAL RTE LD $/RT ______ = ________

x CANAL RTE $/RT ______ = ________

LOAD PORT CHARGES $ = ________

DISCH PORT CHARGES $ = ________

ADJUSTMENTS $ = ________

FUEL COSTS $ = ________

TOTAL VOYAGE COSTS $ = ________

NETBACK $ = (NET FRT LESS TOT VOY COSTS) ________

NETBACK $ ________ ÷ TOT DAYS ________ = NETBACK $/DAY ________

EQUIV TIME CHARTER RATE

(NETBACK $/DAY x 365) ÷ (12 x DWT) = $/DWT/MO ________

PROFIT CALCULATION

SHIP COST: $/DAY ______ x DAYS ______ = $ ________

OR

OR $/DWT/MO ______ x $\frac{12}{365}$ x DAYS ______ = $ ________

VOY PROFIT $ = NETBACK $ ______ LESS SHIP COST = $ ________

$ PROFIT/DAY = VOY PROFIT $ ÷ DAYS = $/DAY ________

FIGURE 2

STANDARD DATA REQUIRED FOR ANALYSIS OF ALTERNATIVES AND SELECTION OF STRATEGIES

COST ELEMENTS	PHYSICAL CHARACTERISTICS
SHIP COSTS (Capital Cost, Financing Method and Terms, Required Date of Return on Capital, Asset Life, Depreciation Method)	1. SHIP CHARACTERISTICS [Speed, Fuel Consumption, Size (or deadweight), Cubic Capacity, Cargo Handling Equipment, Number of Tanks or Holds, Pumping Rates]
OPERATING COSTS (Manning, Insurance, Provisions, Repairs)	2. VOYAGE CHARACTERISTICS (Distances, Port Days, Port Drafts, Canal Days, Canal Drafts, Zone Changes, Terminal Facilities and Capabilities, Bunkering)
VOYAGE COSTS (Port Charges, Fuel Costs, Canal Costs, Cargo Handling Costs)	

FIGURE 3

TRANSPORTATION COST CALCULATIONS

1. SEA DAYS = Total Round Voyage Distance/Ship's Speed x 24

   ANNUAL VOYAGES = $\frac{\text{Annual Operating Days}}{\text{Sea Days + Port Days/Voyage}}$ = V

2. CARGO TONS PER VOYAGE = Deadweight - (Water + Stores + Fuel Consumed at Sea and in Port) = TPV

3. TOTAL ANNUAL REVENUE = V x TPV x $/Ton (Freight Rate) = TR

4. ANNUAL VOYAGE COSTS = [(Fuel Cost) x (Total Fuel @ Sea + Total Fuel in Port)] + [(Port Charges Loading + Port Charges Discharging)] x AV = VC

5. ANNUAL OPERATING COST = Manning + Insurance + Provisions + Repairs + Miscellaneous = OC

6. ANNUAL FINANCIAL COST = Ship Cost x % Financed x Amortization Factor @ Interest Rate (i) = FC

7. TOTAL ANNUAL PROFIT = TR - (VC + OC + FC) = TP

* A time charter rate may be substituted for items 5 and 6

EXHIBIT A-1

DATA FILES

(AMENDED 9/27/82)

U.S. FLAG

SHIP FILES

BULK & TANKER SHIPS

(RATES PER DWT/MO.)

Ship #	Ship Name Flag	DWT	Type	T/C Rate New	T/C Rate Second Hand
100	US	25K	Bulk	$ 37.60	$ 22.59
101	US	80K	Bulk	19.63	10.85
200	US	25K	Tanker	37.93	23.60
201	US	35K	Tanker	31.84	19.05
202	US	40K	Tanker	30.00	18.00
203	US	50K	Tanker	25.72	15.29
204	US	60K	Tanker	21.74	12.87
205	US	80K	Tanker	17.42	10.38
206	US	90K	Tanker	16.31	9.65
207	US	120K	Tanker	13.84	8.04
208	US	150K	Tanker	12.23	6.98
209	US	175K	Tanker	11.58	6.48

CONTAINERSHIPS

(Rates Per TEU/Mo.)

	Flag	TEU's		
300	US	600 TEU	$1,894.00	$1,224.00
301	US	1,000 TEU	1,253.00	808.00
302	US	1,200 TEU	1,115.00	688.00
303	US	1,400 TEU	1,057.00	644.00
304	US	1,600 TEU	992.00	598.00
305	US	2,000 TEU	875.00	521.00
307	US	2,400 TEU	805.00	463.00

Rev. 1
12/08/82

EXHIBIT A-2
SHIP FILES
(CONTINUED)

GENERAL CARGO
(RATES PER DWT/MO.)

Ship #	Ship Name Flag	DWT	Type	T/C Rate New	T/C Rate Second Hand
400	US	11K	General Cargo	$ 87.42	$ 57.21
401	US	14K	General Cargo	76.29	48.01
402	US	16K	General Cargo	73.81	45.20
403	US	20K	General Cargo	57.98	34.77
404	US	24K	General Cargo	56.19	33.37
405	US	30K	General Cargo	50.49	29.23

VOYAGE FILES

Voyage #	Voyage Name
100	1,500 Mi. - Bulk
101	2,500 Mi. - Bulk
102	5,000 Mi. - Bulk
103	10,000 Mi. - Bulk
200	1,500 Mi. - Tanker
201	2,500 Mi. - Tanker
202	5,000 Mi. - Tanker
203	10,000 Mi. - Tanker
300	1,500 Mi. - Container
301	2,500 Mi. - Container
302	5,000 Mi. - Container
303	10,000 Mi. - Container
400	1,500 Mi. - General Cargo
401	2,500 Mi. - General Cargo
402	5,000 Mi. - General Cargo
403	10,000 Mi. - General Cargo

EXHIBIT A-3

ITINERARIES

Voyage Number	400	401	402	403
Voyage Type	Gen. Cargo	Gen. Cargo	Gen. Cargo	Gen. Cargo
Distance - Loaded	1,500	2,500	5,000	10,000
Distance - Ballast	1,500	2,500	5,000	10,000
Bunker Distance	1,500	2,500	5,000	10,000
Port Days - Loaded	6.0	6.0	6.0	6.0
Port Days - Discharged	6.0	6.0	6.0	6.0
Fuel Price - HVF	180	180	180	180
Fuel Price - D.O.	300	300	300	300
Port Charges LD/DWT	$25	$25	$25	$25
Port Charges Disch/DWT	25	25	25	25
Draft Limit - Load	70	70	70	70
Draft Limit - Discharge	40	40	40	40
Cubic Foot/Ton	50	50	50	50

Rev. 1
12/08/82

EXHIBIT A-4
U.S. FLAG
ESTIMATED AVERAGE OPERATING COSTS FOR OCEANGOING VESSELS
(RESULTS - SUMMARIZED IN TERMS OF TIME CHARTER EQUIVALENT)

Identification #	100	101	200	201	202	203	204	205	206	207	208	20[illegible]
Vessel Type:	BULK	BULK	TANKER	TANKER	TANKER	TANKER	TANKER	TANKER	TANKER	TANKER	TANKER	TANKER
DWT: (Long Tons)	25,000	80,000	25,000	35,000	40,000	50,000	60,000	80,000	90,000	120,000	150,000	175,000
Flag:	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
1. Investment ($000's)												
- New	55,000	110,000	55,000	67,000	72,000	80,000	85,000	90,000	95,000	110,000	125,000	140,000
- Second Hand	22,000	44,000	22,000	26,000	29,000	32,000	34,000	36,000	38,000	44,000	50,000	56,000
2. Fixed Charges ($000's)*												
70% Financing @15% For 15 Years**	38.5/15.4	77/30.8	38.5/15.4	46.9/18.2	50.4/20.3	56.0/22.4	59.5/23.8	63/25.2	66.5/26.6	77.0/30.8	87.5/35.0	98/39.2
New	6,584	13,168	6,584	8,021	8,619	9,577	10,176	10,714	11,373	13,168	14,964	16,760
Second Hand	2,634	5,267	2,634	3,113	3,472	3,831	4,070	4,310	4,549	5,267	5,986	6,704
3. Vessel Charges ($000's)												
Wages And Allowances	2,700	3,000	2,900	2,900	2,900	3,000	3,000	3,000	3,000	3,100	3,100	3,100
Subsistence	68	85	80	80	80	85	85	85	85	88	88	[illegible]
Stores and Supplies (Inc. Lubes)	160	215	160	160	165	170	180	200	210	230	250	28[illegible]
Maintenance and Repairs	450	700	550	600	625	700	725	800	825	925	975	1,000
Insurance: New and Second Hand	733/200	1100/400	815/365	900/475	975/500	1050/575	1100/650	1150/800	1250/880	1350/930	1400/980	1500/1010
Other	45	50	45	45	50	50	50	50	50	50	50	50
Subtotal	4156/3623	5150/4450	4550/4100	4685/4260	4795/4320	5055/4580	5140/4690	5285/4935	5420/5050	5743/5323	5863/5443	6018/5528
Total Annual Cost - New	10,740	18,318	11,134	12,706	13,414	14,632	15,316	16,059	16,793	18,911	20,827	22,778
Second Hand	6,257	9,717	6,734	7,373	7,792	8,411	8,760	9,245	9,599	10,590	11,429	12,232
T/C Equivalent***- New	$37.60	19.63	37.93	31.84	30.00	25.72	21.74	17.42	16.31	13.04	12.23	11.58
Second Hand	22.59	10.85	23.60	19.05	18.00	15.29	12.87	10.38	9.65	8.04	6.98	6.48
Characteristics												
Crew Size	23	26	25	25	25	26	26	26	26	27	27	27
Capacity (Cubic)	1,187,790	3,217,000	1,263,316	1,729,966	1,547,465	2,327,000	2,882,853	3,397,307	3,823,710	5,100,000	6,300,000	7,350,000
LOA (Feet)	567.2	896.2	587	711	689	736	731	811	894	883	901	906
Beam (Feet)	74.8	106.0	84	84	80	102	105	125	106	138	160	173
Draft (Feet)	33.71	45.83	35	32.81	35.06	400	43.31	43.59	49.08	51.75	55	57.3
TPI (Tons Per Inch)	86	193	90	117	123	139	159	202	195	254	288	317
Horsepower	11,200	24,000	13,600	14,000	15,000	17,000	20,000	26,000	24,500	26,000	26,000	26,700
Speed	15.5	16.5	16	16	16.5	16.5	15.5	16.5	16	16.5	16.0	16.5
Fuel (Tons Per Day)												
Sea - HVF	60	122	74	40	80	88	100	125	122	128	133	138
Port - HVF	7	15	13	16	15	15	16	19	19	20	21	22
Actual DWT	25,112	82,199	25,800	35,100	39,335	50,060	62,005	81,116	90,637	120,319	150,000	173,380

*Annual Cost
**Figures in millions.
***Includes ship recovery value in 15th year - 25% of original cost of new ship and 10% of cost of second hand ship. Financing payments made semi-annually, 350 operating days per year

EXHIBIT C-1

ESTIMATED AVERAGE OPERATING COSTS FOR OCEANGOING VESSELS

(RESULTS - SUMMARIZED IN TERMS OF TIME CHARTER EQUIVALENT)

BULK CARRIERS - WEST GERMAN FLAG

Vessel Type:	Bulk	Bulk	Bulk	Bulk	Bulk	Bulk	Bulk	Bulk	Bulk	Bulk	Bulk
DWT: (Long Tons)	15,000	25,000	35,000	40,000	45,000	50,000	60,000	80,000	100,000	120,000	150,000
Flag:	W. German	W. German	W. German	W. German	W. German	W. German	W. German	W. German	W. German	W. German	W. German
1. Investment ($000's)											
New	17,500	19,000	13,500	19,900	23,500	25,500	30,000	34,000	38,000	42,000	46,000
Second Hand	5,800	7,800	8,300	8,400	8,500	8,700	9,000	9,100	9,300	9,500	10,000
2. Fixed Charges ($000's)*											
70% Financing @15% for 15 Yrs.**											
- New	2,095	2,275	2,334	2,382	2,813	3,053	3,591	4,070	4,549	5,028	5,507
- Second Hand	700	934	994	1,006	1,018	1,041	1,077	1,089	1,113	1,137	1,197
3. Vessel Charges ($000's)											
Wages and Allowances, Subsistence	1,440	1,460	1,480	1,485	1,490	1,500	1,510	1,525	1,540	1,550	1,560
Stores & Supplies (Incl. Lubes), Maintenance and Repairs	242	252	258	265	274	283	292	325	355	383	460
Insurance	188	216	224	229	234	241	247	250	255	261	278
Other	100	100	100	100	100	100	90	90	90	90	90
Subtotal	1,970	2,028	2,062	2,080	2,098	2,124	2,139	2,190	2,240	2,284	2,388
Total Cost-New	4,065	4,303	4,396	4,462	4,911	5,177	5,730	6,260	6,789	7,312	7,895
Second Hand	2,670	2,962	3,056	3,086	3,116	3,165	3,216	3,279	3,353	3,421	3,585
T/C Equivalent***-New	$23.78	15.11	11.03	9.79	9.59	9.10	8.40	6.88	5.97	5.36	4.63
Second Hand	15.89	10.63	7.84	6.93	6.22	5.69	4.82	3.68	3.01	2.56	2.15
Characteristics											
Capacity (Cubic)	690,000	1,880,000	1,456,000	1,653,000	1,878,000	2,089,000	2,621,000	3,300,000	4,176,000	4,951,000	5,977,000
LOA (Feet)	472	567	643	600	666	706	738	850	830	878	918
Beam (Feet)	68	75	80	95	90	105	106	106	117	128	141
Draft (Feet)	30.8	33.7	36.6	39	41	38.5	41	46	50	52.7	55.6
TPI (Tons Per Inch)	62	86	105	115	125	136	154	191	218	241	298
Horsepower	7,800	10,700	11,550	13,324	13,564	13,700	18,500	20,300	21,100	23,900	20,400
Speed (Knots)	14.8	15.5	15.3	15	15	15	15.8	17.5	15.5	15.5	14.5
Fuel (Tons Per Day)											
Sea - HVF/D.O.	23/1.5	39/2.0	35.5/2.5	44.5/2.5	49/2.5	52/2.5	56/2.5	67/-	72/-	81/-	94/-
Port - HVF/D.O.	-/2.0	-/2.0	-/2.5	-/2.5	-/2.5	-/2.5	-/2.5	-/2.5	-/3.0	-/3	-/3.0
Identification #	500	501	502	503	504	505	506	507	508	509	510

*Annual Cost

**Figures in millions.

***Includes ship recovery value in 15th year - 25% of original cost of new ship and 10% of cost of second hand ship. Financing payments made semi-annually, 350 operating days per year.

12/08/82

EXHIBIT C-7
ESTIMATED AVERAGE OPERATING COSTS FOR OCEANGOING VESSELS
(RESULTS - SUMMARIZED IN TERMS OF TIME CHARTER EQUIVALENT)

Tankers - UK Flag

Vessel Type:	Tanker	Tanker	Tanker	Tanker	Tanker	Tanker	Tanker	Tanker	Tanker	Tanker	Tanker
DWT: (Long Tons)	20,000	25,000	35,000	40,000	50,000	60,000	80,000	90,000	120,000	150,000	175,000
Flag:	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK
1. Investment ($000's)											
New	25,000	28,000	30,000	31,500	33,000	34,000	35,000	36,000	40,000	44,000	46,500
Second Hand	8,000	8,000	8,000	8,000	8,000	8,000	8,500	8,500	8,600	9,000	9,100
2. Fixed Charges ($000's)*											
70% Financing @15% for 15 Yrs.**											
- New	3,113	3,352	3,591	3,771	3,950	4,070	4,190	4,310	4,788	5,267	5,567
- Second Hand	958	958	958	958	958	958	1,018	1,018	1,030	1,077	1,089
3. Vessel Charges ($000's)											
Wages and Allowances Subsistence	1,199	1,199	1,210	1,210	1,210	1,222	1,222	1,234	1,234	1,246	1,246
Stores & Supplies (Incl. Lubes) Maintenance and Repairs	316	320	328	336	344	352	361	387	438	487	530
Insurance	210	220	230	242	254	265	275	286	265	258	250
Other	110	110	110	100	100	100	100	90	90	90	90
Subtotal	1,835	1,849	1,878	1,888	1,908	1,939	1,958	1,997	2,027	2,081	2,116
Total Cost-New	4,948	5,201	5,469	5,659	5,858	6,009	6,148	6,307	6,815	7,348	7,683
Second Hand	2,793	2,807	2,836	.,846	2,866	2,897	2,976	3,015	3,057	3,158	3,205
T/C Equivalent***-New	$21.76	18.30	13.75	12.45	10.33	8.82	6.76	6.17	5.00	4.32	3.87
Second Hand	12.57	10.10	7.29	6.40	5.17	4.34	3.35	3.01	2.29	1.89	1.65
Characteristics											
Capacity (Cubic)	-	-	-	-	-	-	-	-	-	-	-
LOA (Feet)	544	561	617	600	645	687	763	843	865	942	944
Beam (Feet)	795	82	88	106	120	125	144	124	134	159	151
Draft (Feet)	30.3	31.3	34.3	37.5	37	39.6	39.8	45.4	55	50.8	61.1
TPI (Tons Per Inch)	73	88	103	119	133	161	185	210	237	284	305
Horsepower	9,900	11,600	11,480	14,000	16,500	15,000	20,300	23,200	23,900	31,700	32,000
Speed (Knots)	1.5	15.5	15.5	15.5	16.2	15	16.75	16	16	15.5	16.5
Fuel (Tons Per Day)											
Sea - HVF/D.O.	28/1.5	39/1.5	40.8/2.0	44.5/2.0	56.5/3.0	58/3.0	71/-	79/-	85/-	98/-	113/-
Port - HVF/D.O.	1.5	1.5	2.0	2.5	3.0	3.0	3.0	3.2	-/3.5	-/3.5	-/3.5
Identification #	600	601	602	603	604	605	606	607	608	609	610

*Annual cost
**Figures in millions.
***Includes ship recovery value in 15th year - 25% of original cost of new ship and 10% of cost of second hand ship. Financing payments made semi-annually, 350 operating days per year.

12/08/82

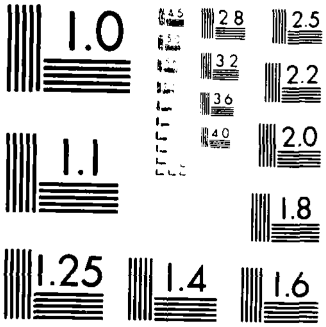
EXHIBIT A

U. S. FLAG SHIP OPERATING AND CAPITAL COSTS

REDUCED TO TIME CHARTER EQUIVALENT RATES

AD-A136 867 PROCEEDINGS: ECONOMIC AND SOCIAL ANALYSIS WORKSHOP HELD AT ST LOUIS MISSO..(U) ARMY ENGINEER INST FOR WATER RESOURCES FORT BELVOIR VA L G ANTLE OCT 83 IWR-83-P-40 2/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

The remainder of this memorandum describes the development of the exhibits.

II. EXHIBIT A - U.S. FLAG SHIP OPERATING AND CAPITAL COSTS REDUCED TO TIME CHARTER EQUIVALENT RATES

The enclosed statement provides the development of the time charter equivalent rates associated with the selected ship, operating and capital costs. The time charter analysis program is used and is accessed by the simple command, RUN TIME.

The system permits calculation of breakeven time charter rates by solving for a required 0% rate of return. A ceiling time charter rate of $20.00/DWT/Mo. was input into the programs to avoid excessive run-up of CRU's (Computer Resource Units) in performing calculations. This ceiling, however, is too low for the smaller vessels (i.e., under 80,000 DWT), and therefore, the user of the system merely adds a 0 to the vessel DWT input, and of course, the resulting T/C rate must be adjusted by moving the decimal one place to the right.

We have included one example of the various cost and cash flow schedules that can be provided by the system following the 25,000 DWT bulk time charter case.

The time charter analysis program, although specifically designed for tanker and dry bulk vessels, can also be used for containerships. The results for containerships is shown as $ per TEU per month. The TEU capacity of the vessel is shown in place of DWT. In order to accommodate containerships, two zeros are added to the TEU equivalents (with the exception of the 600 TEU vessel, where three zeros are added). The results developed are then manually adjusted as shown in the exhibits.

```
RUN TIME

TIME          11:24EDT    08/25/82

MMS TIME CHARTER  DCF/CASH FLOW PROGRAM (MOD4)

 1 CHARTER DWT          =?25112

 2 INIT CHR RTE $/DWT/M=?99

   REQ DCF= ?0

 5 CHARTER TERM YRS     =?15

 6 ESCAL OPER CST $/YR =?

 7 OPER CST ESCAL %/YR =?

 8 NON ESC OPR CST $/YR=?4156000

 9 SPEC CST YR         =?

11 NO. PRE OPR YR PAYMT=?

12 SHIP COST $          =?55000000

13 TYPE LOAN 1 OR 2     =?1

14 LOAN INTER RTE %    =?15

15 AMOUNT OF LOAN     $=?33500000

16 LOAN TERM YRS       =?15

   PAYMENTS (1)ANNUAL (2)SEMI-ANNUAL (3)MONTHLY ?2

17 SHIP LIFE YRS       =?20

18 SHIP VAL END CHAR   =?13750000

19 TAX RATE %          =?0

20 TYPE DEPREC S OR A = ?S

MODIFY LINE NUMBER:?

T/C RATE GREATER THAN $20

INPUT SCHEDULE REQ:?R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?1

 1 CHARTER DWT          =?251120

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=     3.5824
```

New

Add zero = $35.82

```
INPUT SCHEDULE REQ:?R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?3623000

MODIFY LINE NUMBER:?12

12 SHIP COST $          =?22000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?15400000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR   =?2200000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=     2.2592
```

2nd HAND

```
INPUT SCHEDULE REQ:?R
```

Add 0 =

U.S FLAG

25000 DWT

BULK

```
R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?1

 1 CHARTER DWT          =?82199

MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?5150000

MODIFY LINE NUMBER:?12

12 SHIP COST $         =?110000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?77000000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?27500000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=   19.6300

INPUT SCHEDULE REQ:?R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?4450000

MODIFY LINE NUMBER:?12

12 SHIP COST $         =?44000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?30800000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?4400000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=   10.8459

INPUT SCHEDULE REQ:?

INPUT SCHEDULE REQ:?
```

U.S FLAG
80000 DWT
BULK

NEW

2nd HAND

```
R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?1

 1 CHARTER DWT         =?120319

MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?5893000

MODIFY LINE NUMBER:?12

12 SHIP COST $         =?145000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?101500000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?36250000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=   17.0305

INPUT SCHEDULE REQ:?R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?5323000

MODIFY LINE NUMBER:?12

12 SHIP COST $         =?60000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?42000000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?6000000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=    9.5654

INPUT SCHEDULE REQ:?
```

U.S. Flag
120000 DWT
Tanker

New

2nd Hand

```
R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?1

 1 CHARTER DWT          =?120000

MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?6175000

MODIFY LINE NUMBER:?12

12 SHIP COST $         =?80000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN    $=?56000000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?20000000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=   11.5397

INPUT SCHEDULE REQ:?R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?5535000

MODIFY LINE NUMBER:?12

12 SHIP COST $         =?28000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN    $=?19600000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?2800000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=    6.6866

INPUT SCHEDULE REQ:?
```

U.S FLAG
1200 TEU
CONTAINERSHIP

$1154

$668.66

```
R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?1

 1 CHARTER DWT          =?300000

MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?5230000

MODIFY LINE NUMBER:?12

12 SHIP COST $          =?100000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?70000000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?25000000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=     5.0485

INPUT SCHEDULE REQ:?R

REPEAT CALC WITH MODIFICATIONS
MODIFY LINE NUMBER:?8

 8 NON ESC OPR CST $/YR=?4810000

MODIFY LINE NUMBER:?12

12 SHIP COST $          =?40000000

MODIFY LINE NUMBER:?15

15 AMOUNT OF LOAN     $=?28000000

MODIFY LINE NUMBER:?18

18 SHIP VAL END CHAR  =?4000000

MODIFY LINE NUMBER:?

BRK EVEN T/C RATE (0 NET CASH FLOW)=     2.9232

INPUT SCHEDULE REQ:?

USED   645.97 UNITS
BYE
00646.48  CRU    0001.49  TCH    0026.45  KC

OFF AT 12:34EDT 08/20/82
```

U.S

30000 DWT

General Cargo

~ 50.49 New

$ 29.23 (2nd hand)

102 BLANK

EXHIBIT B

SHIP AND VOYAGE DATA FILES

III. EXHIBIT B - SHIP AND VOYAGE FILES

A file is created for each ship and voyage. The ship data files are straight forward and self-explanatory with the exception of the container vessels (ship #'s 300 - 305). Here the data had to be input in a certain way so that when the data is used, results in terms of TEU's, rather than DWT can be provided.

Item #5 Summer DWT, represents the number of TEU's multiplied by 10. This number is used to calculate port charges based on the port costs stored in the voyage file. Port costs include stevedoring and cargo handling costs, as well as normal port charges and dues.

Items #9 and #10 are not actual cubics, as is the case for non-container vessels. These cargo cubics are derived values to assure that costs are developed on a TEU, as opposed to DWT basis. The computer programs permit cargo restriction by cubic. Therefore, a stowage factor of 40 is shown in the voyage file and the cubic is derived by multiplying 40 times the TEU capacity of the vessel (i.e., a 600 TEU vessel has for the purpose of calculation, 24,000 cubic feet of capacity). The actual vessel DWT is shown in items #21 (Winter DWT), and #22 (Tropical DWT) of the ship file. The breakeven time charter (item #29) rate has the decimal moved one place to the left to offset the extra digit added to the number of TEU's. The ship cost shown in each file (item #18) is based on second hand ship costs, as well as operating and financial costs.

The voyage files are also self-explanatory, again with the exception of the container voyages where the stowage factor (item #32) is used specifically for calculations; and port charges have been adjusted by moving the decimal point to the left to reflect the fact that the number shown for DWT in the containership file represents 10 times the number of actual TEU's on the ship.

```
INPUT SHIP NO. ?101

REC # =    2
 1 SHIP NO        =         101.
 2 NAME:    US80K BULK
 3 SHIP CODE      =   HVF
 4 SHIP TYPE      =   BULK
 5 SUMMER DWT     =       82199.
 6 SERV SPEED LD=      16.00
 7 SERV SPEED BL=      17.00
 8 DRAFT (SUM)    =      45.83
 9 LIQUID CUBIC =     3217000.
10 GRAIN CUBIC  =     3217000.
11 HV FUEL SEA/D=     122.00
12 HVFUEL PORT/D=      15.00
13 DIESEL SEA/D =       0.
14 DIESEL PORT/D=       0.
15 SUEZ NRT       =           0.
16 PANAMA NRT     =           0.
17 WATER & STRS =         200.
18 SHIP COST $   =   30800000.
19 TONS/INCH      =         193.
20 PANAMA DWT     =           0.
21 WINTER DWT     =       79988.
22 TROPICAL DWT =       84410.
23 SUEZ DWT       =           0.
24 BUNKER CAP LT=           0.
25 OPER CST/DAY =       12192.
26 FINAN CHG/DAY=       14430.
27 OPER DAYS/YR =         350.
28 BRK EV TIM CH=      10.85
```

INPUT SHIP NO. ?207

```
REC # =  10
 1 SHIP NO        =         207.
 2 NAME:    US120K TANKER
 3 SHIP CODE      =  HVF
 4 SHIP TYPE      =  TANKER
 5 SUMMER DWT     =      120319.
 6 SERV SPEED LD=        16.00
 7 SERV SPEED BL=        17.00
 8 DRAFT (SUM)    =      51.75
 9 LIQUID CUBIC =      4756339.
10 GRAIN CUBIC   =     4756339.
11 HV FUEL SEA/D=      128.00
12 HVFUEL PORT/D=       20.00
13 DIESEL SEA/D =        0.
14 DIESEL PORT/D=        0.
15 SUEZ NRT       =           0.
16 PANAMA NRT     =           0.
17 WATER & STRS =           250.
18 SHIP COST $   =     60000000.
19 TONS/INCH      =         254.
20 PANAMA DWT     =           0.
21 WINTER DWT     =      117033.
22 TROPICAL DWT =        123605.
23 SUEZ DWT       =           0.
24 BUNKER CAP LT=             0.
25 OPER CST/DAY =        14584.
26 FINAN CHG/DAY=        19679.
27 OPER DAYS/YR =          350.
28 BRK EV TIM CH=        9.57
```

```
INPUT SHIP NO. ?302

REC # =  15
 1 SHIP NO        =         302.
 2 NAME:    US 1200 TEU
 3 SHIP CODE      =  HVF
 4 SHIP TYPE      =  CONTAINER
 5 SUMMER DWT     =       12000.
 6 SERV SPEED LD=       22.00
 7 SERV SPEED BL=       24.00
 8 DRAFT (SUM)    =     34.00
 9 LIQUID CUBIC =       48000.
10 GRAIN CUBIC    =     48000.
11 HV FUEL SEA/D=     171.00
12 HVFUEL PORT/D=      13.00
13 DIESEL SEA/D =        0.
14 DIESEL PORT/D=        0.
15 SUEZ NRT       =           0.
16 PANAMA NRT     =           0.
17 WATER & STRS =           150.
18 SHIP COST $    =   28000000.
19 TONS/INCH      =           0.
20 PANAMA DWT     =           0.
21 WINTER DWT     =       26663.
22 TROPICAL DWT =         26663.
23 SUEZ DWT       =           0.
24 BUNKER CAP LT=             0.
25 OPER CST/DAY =         15164.
26 FINAN CHG/DAY=          9183.
27 OPER DAYS/YR =           350.
28 BRK EV TIM CH=      66.90
```

INPUT SHIP NO. ?405

```
REC # =  25
 1 SHIP NO        =         405.
 2 NAME:    US30K GEN.CARGO
 3 SHIP CODE      =  HVF
 4 SHIP TYPE      =  GEN.CARGO
 5 SUMMER DWT     =       30000.
 6 SERV SPEED LD=      18.50
 7 SERV SPEED BL=      19.50
 8 DRAFT (SUM)   =      36.00
 9 LIQUID CUBIC =    1600000.
10 GRAIN CUBIC   =    1600000.
11 HV FUEL SEA/D=    124.00
12 HVFUEL PORT/D=     16.00
13 DIESEL SEA/D =      0.
14 DIESEL PORT/D=      0.
15 SUEZ NRT      =            0.
16 PANAMA NRT    =            0.
17 WATER & STRS =          150.
18 SHIP COST $   =   40000000.
19 TONS/INCH     =            0.
20 PANAMA DWT    =            0.
21 WINTER DWT    =       30000.
22 TROPICAL DWT =       30000.
23 SUEZ DWT      =            0.
24 BUNKER CAP LT=            0.
25 OPER CST/DAY =       13178.
26 FINAN CHG/DAY=       13118.
27 OPER DAYS/YR =         350.
28 BRK EV TIM CH=     29.23
```

INPUT VOY NO. ?102

REC NO. 4

```
 1 VOYAGE NUMBER      =          102.
 2 NAME:    BULK-5000MI.
 3 DIST LOADED        =     5000.
 4 DIST BALLAST       =     5000.
 5 BKR DIST LD PORT   =     5000.
 6 BKR DIST INTR PORT=         0.
 7 FREEBD ZONE DIST   =        0.
 8 CANAL DISTANCE     =        0.
 9 CNL DYS <= 60K DWT=     0.
10 CANAL DAYS > 60000=     0.
11 PORT DAYS  LD      =     2.00
12 LOAD RATE 1000 T/D=     0.
13 PORT DAYS  DISCH   =     2.00
14 DISCH RATE   TH T/D=    0.
15 FUEL PRC BKR C $/L=   180.00
16 FUEL PRICE HVF $/L=   180.00
17 FUEL PRICE DO $/LT=   300.00
18 SUEZ RATE LD $/RT =     0.
19 SUEZ RATE BAL $/RT=     0.
20 PANAMA RTE LD $/RT=     0.
21 PANAMA RTE BAL     =    0.
22 PORT CHG  LD     $=        0.
23 PT CHG  LD    $/DWT=    0.150
24 PORT CHG  DISCH  $=        0.
25 PT CHG  DCH   $/DWT=    0.500
26 DRAFT LIM LD PORT =   40.00
27 DRAFT LIM DSCHG PT=   70.00
28 DRAFT LIM CANAL    =    0.
29 LOADING PORT ZONE =
30 INTERMED PORT ZONE=
31 FREEBOARD ZONE     =
32 STOWAGE FACTOR     =   36.00
33 CARGO RESTRICTION =        0.
34 STAND. SCALE $/LT=    0.
35 WORLDSCALE FLAT    =    0.
36 DAYS IN CANAL BAL =     0.
37 SOURCE PRICE  $/LT=     0.
38 VOY DESCRIPT :
```

```
INPUT VOY NO. 302

REC NO.    11
 1 VOYAGE NUMBER      =              302.
 2 NAME:    CONTAINER-5000MI.
 3 DIST LOADED        =       5000.
 4 DIST BALLAST       =       5000.
 5 BKR DIST LD PORT   =       5000.
 6 BKR DIST INTR PORT=           0.
 7 FREEBD ZONE DIST   =           0.
 8 CANAL DISTANCE     =           0.
 9 CNL DYS  = 60K DWT=       0.
10 CANAL DAYS   60000=       0.
11 PORT DAYS  LD      =       3.00
12 LOAD RATE 1000 T D=       0.
13 PORT DAYS  DISCH   =       3.00
14 DISCH RATE   TH T/D=      0.
15 FUEL PRC BKR C $/L=    180.00
16 FUEL PRICE HVF $/L=    180.00
17 FUEL PRICE DO $/LT=    300.00
18 SUEZ RATE LD $/RT =       0.
19 SUEZ RATE BAL $/RT=       0.
20 PANAMA RTE LD $/RT=       0.
21 PANAMA RTE BAL     =       0.
22 PORT CHG  LD      $=           0.
23 PT CHG  LD   $/DWT=     20.000
24 PORT CHG  DISCH  $=           0.
25 PT CHG  DCH  $/DWT=     30.000
26 DRAFT LIM LD PORT =     40.00
27 DRAFT LIM DSCHG PT=     70.00
28 DRAFT LIM CANAL    =      0.
29 LOADING PORT ZONE =
30 INTERMED PORT ZONE=
31 FREEBOARD ZONE     =
32 STOWAGE FACTOR     =     40.00
33 CARGO RESTRICTION =           0.
34 STAND. SCALE $/LT=       0.
35 WORLDSCALE FLAT    =      0.
36 DAYS IN CANAL BAL =       0.
37 SOURCE PRICE  $/LT=       0.
38 VOY DESCRIPT :
```

ITINERARY

Voyage Number Voyage Type	100 BULK	101 BULK	102 BULK	103 BULK	200 TANKER	201 TANKER	202 TANKER	203 TANKER	300 CONTAINER	301 CONTAINER	302 CONTAINER	303 CONTAINER
Distance Loaded	1,500	2,500	5,000	10,000	1,500	2,500	5,000	10,000	1,500	2,500	5,000	10,000
Distance Ballast	1,500	2,500	5,000	10,000	1,500	2,500	5,000	10,000	1,500	2,500	5,000	10,000
Bunker Distance	1,500	2,500	5,000	10,000	1,500	2,500	5,000	10,000	1,500	2,500	5,000	10,000
Port Days Loaded	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	3.0	3.0	3.0	3.0
Port Days Discharged	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	3.0	3.0	3.0	3.0
Fuel Price - HVF	180	180	180	180	180	180	180	180	180	180	180	180
Fuel Price - D.O.	300	300	300	300	300	300	300	300	300	300	300	300
Port Charges LD/DWT (Per TEU For Containers)	.15	.15	.15	.15	.20	.20	.20	.20	$20	$20	$20	$20
Port Charges Disch./DWT	.50	.50	.50	.50	.50	.50	.50	.50	$30	$30	$30	$30
Draft Limit - Load	70	70	70	70	70	70	70	70	70	70	70	70
Draft Limit - Discharge	40	40	40	40	40	40	40	40	40	40	40	40
Stowage Factor	36	36	36	36	42	42	42	42	40	40	40	40

Add: $15,000 For 25,000 DWT Bulk & Tanker
$10,000 For 35,000 DWT
$5,000 For 60,000 - 80,000 DWT

Rev. 1
9/27/82

ITINERARY

Voyage Number Voyage Type	400 Gen. Cargo	401 Gen. Cargo	402 Gen. Cargo	403 Gen. Cargo
Distance - Loaded	1,500	2,500	5,000	10,000
Distance - Ballast	1,500	2,500	5,000	10,000
Bunker Distance	1,500	2,500	5,000	10,000
Port Days - Loaded	6.0	6.0	6.0	6.0
Port Days - Discharged	6.0	6.0	6.0	6.0
Fuel Price - HVF	180	180	180	180
Fuel Price - D.O.	300	300	300	300
Port Charges LD/DWT	$25	$25	$25	$25
Port Charges Disch/DWT	25	25	25	25
Draft Limit - Load	70	70	70	70
Draft Limit - Discharge	40	40	40	40
Cu. Ft./Ton	50	50	50	50

EXHIBIT C

CASE EXAMPLES

IV. EXHIBIT C - CASE EXAMPLES

The case examples show how ships, voyages and operating costs can be brought together to provide transportation cost/ton as well as voyage summaries. The key information provided by the analysis shows:

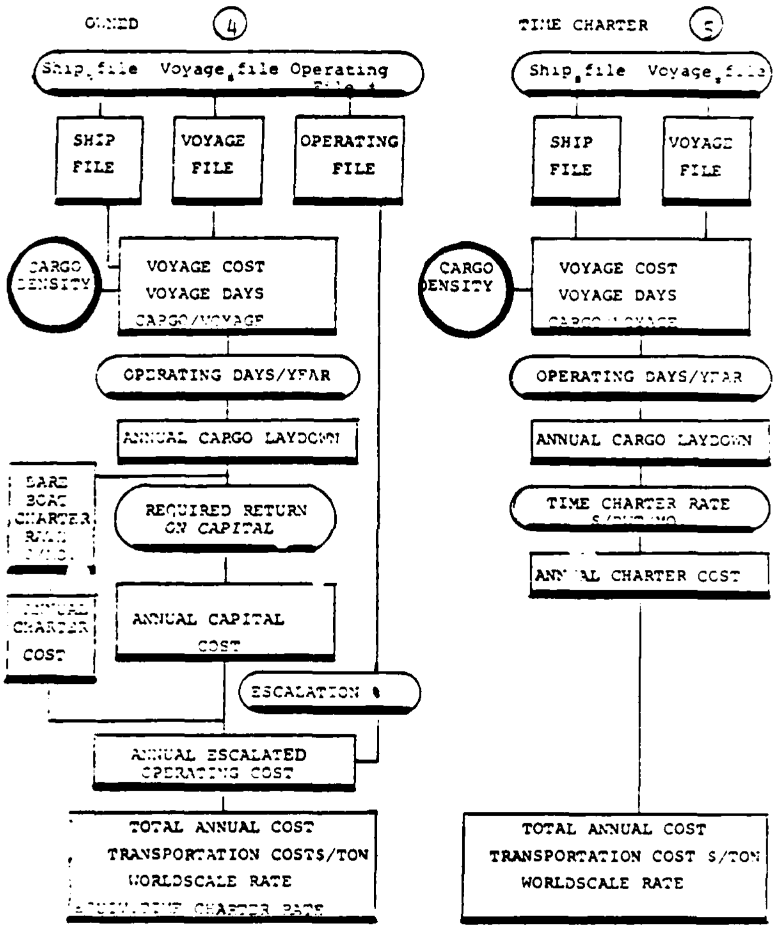
Cargo/Voyage
Days/Voyage
Voyages/Year
Annual Cargo Delivered

Annual Voyage Costs
Annual Charter Costs
Total Costs
Cost/Ton

In the case of the containerships, the resulting transportation cost/ton is in reality, transportation cost per TEU.

The voyage summary shown for the containership has been modified so as to provide costs on a per TEU basis. The restriction due to vessel cubic and the Summer DWT shown are directed results, so as to arrive at the proper cargo DWT (which, in this case, is the number of TEU's).

TRANSPORTATION COST



TC-24

```
RUN TRNSIT


TRNSIT      16:08EDT    09 24 82

 MARINE MANAGEMENT SYSTEMS - TRANSPORTATION COST PROG

SHIP NO. ?101

VOYAGE NO. ?102

OPER SIT NO. ?1

SHIP    :  US90K BULK
VOYAGE :   BULK-5000MI.

MODS:  SHIP + VOY +OR  OPER


CHAR RTE  $ DWT/MOS= ?10.85

CHARTER TERM= ?5

ESCALATION COSTS : BASE $= ?


CARGO TYPE: 1.LIQ 2.DRY BULK ?1DELETED
2

PORT CHG VOY $ ?

 CARGO DWT    =    66238.
 DAYS / VOY   =     29.28
 VOY   YR     =     11.96
 ANNUAL LAYDN=  791897.


ANNUAL VOY COST =  7403728.
 VOY SIT ESCAL %= ?

AVG ANNUAL ESC VOY COST=  7403728.
ANNUAL CHAR SST         = 10262489.
TOTAL COST $            = 17666217.
TRANS COST $ T =     22.31


MORE? ?SUM

VOYAGE SUMMARY
                  BAL.VOY LOAD PORT LOAD VOY DISCH PT   TOTAL
SEA DAYS             12.3       0.      13.0       0.     25.3
PORT DAYS             0.       2.0       0.       2.0      4.0
CANAL DAYS            0.        0.       0.        0.       0.
TOTAL DAYS           12.3      2.0     13.0       2.0     29.3

FUEL COST         269118.    5400.  285938.     5400.  565855.
PORT CHARGES           0.   12330.       0.    41100.   53439.
CANAL CHARGES          0.       0.       0.        0.       0.
TOTAL VOY COSTS   269118.   17730.  285938.    46500.  619284.

LOADING SUMMARY
 SUMMER DWT                               92199.
 RESTRICTION DUE TO:
  LOAD PORT DRAFT
 LOADED DWT                               68697.
 LESS WATER & STORES             200.
 LESS BUNKERS                   1649.
 LESS RESERVE BUNKERS            610.     2459.
 CARGO DWT                                66238.
```


MORE?

TRNCST 16:02EDT 08/24/82

MARINE MANAGEMENT SYSTEMS - TRANSPORTATION COST PROG

SHIP NO. ?302

VOYAGE NO. ?302

OPER CST NO. ?1

SHIP : US 1200 TEU
VOYAGE : CONTAINER-5000MI.

MODS: (SHIP)+(VOY)+OR (OPER)

CHAR RTE $/DWT MOS= ?66.90

CHARTER TERM= ?5

ESCALATION COSTS : BASE $= ?

CARGO TYPE: 1.LIQ 2.DRY BULK ?2

PORT CHG/VOY $?

CARGO DWT = 1200.
DAYS / VOY = 24.15
VOY / YR = 14.49
ANNUAL LAYDN= 17391.

ANNUAL VOY COST = 16995544.
VOY CST ESCAL %= ?

AVG ANNUAL ESC VOY COST= 16995544.
ANNUAL CHAR CST = 9237699.
TOTAL COST $ = 26233243.
TRANS COST $/T = 1508.43

MORE? ?SUM

VOYAGE SUMMARY

	BAL.VOY	LOAD PORT	LOAD VOY	DISCH PT	TOTAL
SEA DAYS	8.7	0.	9.5	0.	18.2
PORT DAYS	0.	3.0	0.	3.0	6.0
CANAL DAYS	0.	0.	0.	0.	0.
TOTAL DAYS	8.7	3.0	9.5	3.0	24.2
FUEL COST	267188.	7020.	291477.	7020.	572705.
PORT CHARGES	0.	240000.	0.	360000.	600000.
CANAL CHARGES	0.	0.	0.	0.	0.
TOTAL VOY COSTS	267188.	247020.	291477.	367020.	1172705.

LOADING SUMMARY

SUMMER DWT		12000.
RESTRICTION DUE TO:		
VESSEL CUBIC		
LOADED DWT		3902.
LESS WATER & STORES	150.	
LESS BUNKERS	1697.	
LESS RESERVE BUNKERS	855.	2702.
CARGO DWT		1200.

MORE? ?TIM

NEW CHAR RTE $/DWT MO=?110.40

ANNUAL CHAR CST = 15244274.
TOTAL COST $ = 32239818.
TRANS COST $/T = 1853.81

MORE? ?

USED 3.34 UNITS
RUN TRNCST

GENERAL REFERENCE

DEEP DRAFT NAVIGATION

DEEP DRAFT NAVIGATION REFERENCES

1. <u>Ships of World</u>

1. Lloyd's Register of Shipping: Register of Ships
2. American Bureau of Shipping, NY, NY
3. Det Norske Veritas (DNV)
4. Bureau Veritas - France
5. Germanischer Lloyd's - Germany
6. Nippon Kayi Kyokai - Japan
7. H. Clarkson & Co. Ltd, London, England - annual
   a. Tanker Register
   b. Bulk Carrier Register
   c. Liquid Gas Carrier Register
8. World Bulk Fleet, Fearnley & Egers Chartering Co. Ltd, Oslo, Norway - annual
9. MerchantFleets ofthe World, MARAD - quarterly listing
10. Analysis of World Tank Ship Fleet, Sun Oil Co - annual
11. Merchant Vessel Fleets Forecasts - Prepared for MARAD by Temple, Barker & Sloane, Inc, 1976.
12. Merchant Vessels of the United States, USCG
13. Transportation Liner on theAtlantic, Gulf and Pacific Coasts, Transportation Series 5, U.S. Army Corps of Engineers - annual

2.	Ships on Order	1. Lloyd's Register of Shipping 2. Shipping Statistics and Economics - H.P. Drewery (Shipping Consultants) Ltd, London 3. Ships on Order - The Motor Ship, London, England 4. U.S. Shipbuilders Report - Marine Engineering Log, Bristol, Conn. 5. World Ships on Order - Fairplay International Shipping Journal, London, England
3.	Port Information	1. Port Dues, Charges and Accommodations - George Philip & Son, London, England 2. Ports of the World - Ben Brothers, Ltd, London, England 3. Fairplay World Ports Directory, Fairplay Publications Ltd, London, England
4.	Ship Owners	1. List of Shipowners - Lloyd's Register of Shipping 2. World Shipping Yearbook - Fairplay Publications, Ltd, London, England 3. Directory of Shipowners, Shipbuilders and Marine Engineers - IPC Industrial Press Ltd, London, England

5.	Shipyard Information	1.	World Shipping Yearbook
		2.	Directory of Shipowners, Shipbuilders and Marine Engineers
6.	World Distance Tables	1.	Distance Tables - Norwegian Shipowners Association
		2.	Table of Distances between Ports, H.O. No. 117, U.S. Navy Hydrographic Office
		3.	Distance between U.S. Ports, NOAA, Dept of Commerce
.	Charter Market	1.	Lloyd's List - Lloyd's of London Press
		2.	Ship Fixture Breakdown - Journal of Commerce, NY, NY
		3.	Weekly Charter Fixture Reported - Maritime Research, Inc., NY, NY
		4.	Fixtures Reported During Month (Shipping Statistics and Economics) - H.P. Drewery
8.	Vessel Position (Movement)	1.	Lloyd's Voyage Record and Lloyd's Shipping Index - Lloyd's of London Press
		2.	Lloyd's Vouage Record - Lloyd's of London Press

9.	Sales and Purchases Information	1. Brokers
		2. Shipping Statistics and Economics - H.P. Drewery
10.	Casualty Data	1. Lloyd's List
		2. Journal of Commerce
11.	Commodities	1. Waterborne Commerce of the U.S., Parts 1-5, Waterways and Harbors, U.S. Army Corps of Engineers, Annual
		2. U.S. Industrial Outlook (YEAR) with 5-Year Projection for 200 Industries, Annual Report, U.S. Department of Commerce (GPO)
		3. Domestic and International Transportation of U.S. Foreign Trade: 1976, Part A, Exports; Part B, Imports; Issued April-May 1979, U.S. Department of Commerce, Bureau of the Census
		4. Long-Term Forecast of U.S. Waterborne Trade, 1976-2000, prepared by Temple, Barker, and Sloane, Inc. for Maritime Administration, U.S. Department of Commerce, November 1977
		5. Minerals Yearbook, 4 volumes, Bureau of Mines, U.S. Department of the Interior, Annual series
		6. Mineral Industry Surveys, Bureau of Mines, monthly and annual
		7. Mineral Facts and Problems, 1980 edition, Bureau of Mines

8. Commodity Data Summaries, Bureau of Mines, annual

9. Foreign Trade Statistics, Bureau of the Census, monthly and annual

10. Mineral Trade Notes, Bureau of Mines, monthly

11. Agricultural Commodities & Chemical Fertilizers, U.S. Department of Agriculture

12. Trade Associations:

    a. American Petroleum Institute
    b. National Coal Association
    c. American Iron and Steel Institute
    d. American Iron Ore Association
    e. National Grain and Feed Association
    f. Coal Exporters Association of the United States

12.	<u>MARDATA</u>	1. Navigation Analysis Center, Water Resources Support Center, Corps of Engineers, Fort Belvoir, VA 22060; Central source of MARDATA for the Corps
		2. Transportation cost analysis
		3. Ship characteristics library
		4. Ships on order library
		5. Charter fixture library
		6. Ships movement library

OPERATIONAL REALITY
VS
ENGINEERING DESIGN STANDARDS
IN THE ECONOMIC EVALUATION OF
HARBOR AND CHANNEL DEEPENING

A TOPIC FOR PRESENTATION
AND DISCUSSION AT THE CORPS OF ENGINEERS
ECONOMIC AND SOCIAL ANALYSIS WORKSHOP
ST. LOUIS, MISSOURI
25-29 October 1982

William T. Hunt, Regional Economist
Robert H. Bartel, Regional Economist

Pacific Ocean Division
Corps of Engineers
October 1982

This topic is a current issue in the on-going BERH review of a harbor deepening project planning study in the Pacific Ocean Division. It has many aspects, and is an example of a general problem encountered in other areas of the economics of water resources planning and development. Essentially, the topic can be reduced for discussion purposes to the question, "How do we reconcile the difference between engineering design criteria specifying 6′ below the keel for harbor depth requirements, and the operational reality in which ships using the harbor routinely use only 2.5′ below the keel?" this difference must somehow be incorporated into the benefit-cost calculation framework, or we can wind up either missing something, double counting, or being internally inconsistent in the analysis--that is, "comparing apples with oranges." Let's start with the 6′ under the keel criterion. Presumably this represents a relatively risk free situation. That is, if this rule is followed there is practically no chance that damage will result from "not enough water under the keel." But the shippers are willing to pay (or willing to take some of this risk) in exchange for the economies of scale gained by loading the ships to a greater draft. To a rational shipper, the gains (transportation cost savings) are at least as great as the risk (or probabilistically expected value of damages) involved.

The rate structure and economic analysis involved is probably somewhat complex if we tried to account for all of the factors involved but the key relevant principle is that the shippers are taking a risk and are willing to pay for it since they are receiving benefits to compensate for this risk. Consider the following hypothetical data:

Existing channel/harbor depth = 35′
"Safe draft (re engineering criteria = 35′-6′ = 29′
Actual draft (usual practice) = 32.5′

Draft	Average Cost Per Ton
29.0′	$16.00
32.5′	$15.50
34.0′	$14.00
37.5′	$13.00

With a proposed harbor deepening to accommodate new

vessels which will operate at 34', there are a number of approaches to conceptually calculate the benefits involved:

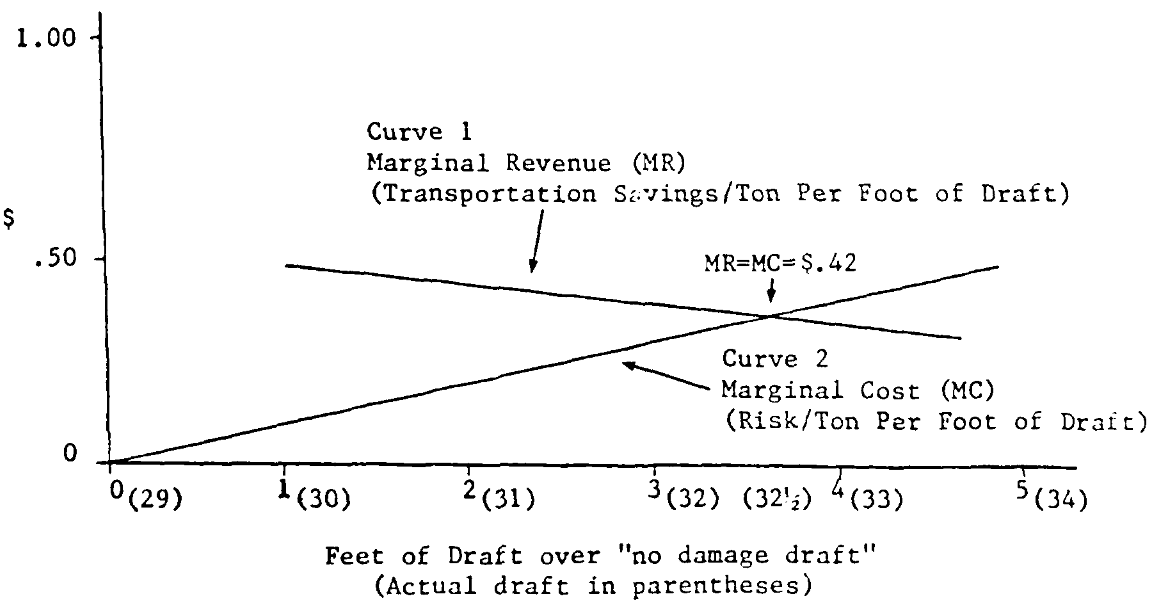
Approach 1: This approach has been supported by BERH staff in reviewing a harbor deepening analysis in POD. Benefits are costs without the project (using "actual draft" costs), less costs with the project (project required is 40', or 34' + 6' under the keel safety requirement), or $15.50 per ton less $14.00 per ton, or $1.50 per ton. But this does not reflect a true comparison of without-project and with-project conditions. It compares "apples with oranges" and incorporates internally inconsistent logic.

Approach 2: Change the engineering criteria and recommend a harbor with a 36.5' draft. Use 32.5' draft costs vs 34' draft costs, for a benefit of $1.50 per ton, to be compared with a less expensive project than approach 1 requires.

Approach 3: Use actual without-project vs with-project cost data, but incorporate an estimate of the risk cost component incurred by the shipper. In the attached graph, Curve 1 represents the marginal revenue, expressed as $ per ton per incremental foot of draft (averaged out over the long term), associated with damages incurred as a result of exceeding the risk free draft. With rational shippers operating at 32.5', this can be viewed as the point such that gains from additional draft are more than offset by expected damage. In other words this is the operational point at which marginal cost = marginal revenue, all other things being equal. The risk cost component, on a per ton basis, can be calculated as the area under Curve 2 up to 32.5' of draft. For the one marginal cost curve drawn on the graph, this amounts to about $.74 per ton. Using this figure as a risk component of total transportation cost, and adding it to the cost per ton without the project of $15.50 (using the actual draft of 32.5') yields a total effective without project cost of $15.50 + $.74 = $16.24 per ton. The benefit using this approach becomes $16.24 less the cost per ton with the project.

These are just three possible ways to deal with the issue addressed here. The above ideas are presented with the hope that they will further stimulate thought and insight into dealing with this and other similar problems encountered in the economics of water resources planning.

Risk Component of Vessel Operating Cost



E V A L U A T I O N
O F
A G R I C U L T U R A L   F L O O D   C O N T R O L
P R O J E C T S

ECONOMIC AND SOCIAL
ANALYSIS WORKSHOP

ST. LOUIS, MO
25-29 OCTOBER 1982

Jesse K. McDonald
Regional Economist
Lower Mississippi Valley Division

THE EVALUATION OF AGRICULTURAL FLOOD CONTROL PROJECTS

I. INTRODUCTION

A. Accurate economic evaluation of the effects of flooding of agricultural areas is essential in determining the feasibility of agricultural flood control projects. This paper attempts to identify the major steps in this evaluation procedure and discuss state-of-the-art methodologies that may be employed in the analysis.

B. The procedures that are discussed herein relate to the guidance provided by the Principles and Standards NED Evaluation Manual. In the last section of this paper, a discussion of the proposed Principles and Guidelines and how they differ from the P&S is presented.

II. Three economic problems associated with water and the use of land and water resources in agricultural production are:

A. Cost of damage to crops and pasture.

1. Loss of net returns from reduced yields because of flooding.

2. Loss of production inputs because of flooding.

B. Variation of associated cost.

1. Future conditions w/o project may result in poor soil drainage conditions that may require more cultivation and more horsepower.

2. Require continuation of costly drainage systems.

3. High maintenance and replacement costs for drainage or flood control systems.

C. Impaired productivity or use of the land resource. Restrict cropping patterns to crops tolerant of flood and/or wet soil conditions.

III. NED BENEFIT

Measured as increased value of output to the nation or reduced cost of maintaining a given level of output.

- Reduced production and associated costs.

- Reduced damage costs from floods.

- Value of increased crop production.

- Economic efficiency of crop production (locational advantage).

IV. COLLECTING BASIC DATA AND DETERMINING FUTURE CONDITIONS.

A. Identify current land use, cropping patterns, and yields.

1. These data are flood-free, i.e., conditions in the flood plain in years in which no damaging floods occur. These yields will reflect other factors that may affect production such as drought, soil fertility, production practices, and the threat of flooding.

2. Data will be stratified, i.e., developed for segments of the flood plain with significantly different cropping patterns, hydrologic conditions, etc.

B. Project future land use, cropping patterns, and yields.

1. With and without project

2. Flood-free

3. Stratified

Future cropping patterns and yields will be consistent with soil capabilities and with water management and production practices accounted for in the production cost analysis.

Increases in yields due to future improvements in technology shall not be included in the evaluation of intensification benefits, but may be included in damage analysis.

C. How do we collect these base data and determine future conditions?

1. Interviews with farmers and other watershed residents are very important. Interviews should not be confined to flood plain farmers. Data collected outside the flood plain can serve as a basis for establishing with project conditions.

2. Agronomists and soil scientists can provide data on the capability of the various soil types, and the effects on production of various water management alternatives.

3. Most universities as well as USDA have developed typical enterprise budgets that can be modified to reflect conditions in the area being studied.

4. In conducting these interviews and collecting these data, only forms approved by OMB shall be used, and each individual survey shall be a part of the supporting data. To my knowledge, the Corps has not developed any agricultural survey forms that have been approved. However, SCS has two OMB-approved forms that we have been using as our basis for form approval in LMVD.

SCS-WS-1
JUNE 1972
FILE CODE WS-14

FORM APPROVED
OMB NO. 40-R3809
U.S. DEPARTMET OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD DAMAGE-AGRICULTURE

Respondent ____________ Years on Farm ________ Farm Location ______________ Watershed ______ Reach ______

Flood Date ____________ No. of Acres Flooded ________ How frequently do floods of this size occur ______________ No. of Acres Flooded by largest flood ______

Damage to Crops and Pasture From Flood of Above Date

Land Use	No. of Acres	Depth of Flood (Ft.)	Duration of Flood (Hrs.)	Expected Yield/Acre If No Flood	Yield/Acre After Flood	Alternate Crop & Yield/Acre	Additional Production Practices Performed Due to Flood	Production Practices Not Performed Due to Flood

REMARKS

Other Agricultural Property Damage From Flood of Above Date

Item	Type	Quantity	Depth of Flood	Estimated Damage (Dollars)

Estimated Land Damage From Flood of Above Date

Kinds	Acres	Productivity Loss	Remarks

Date of Interview ________
By ____________

LAND USE IN TOTAL FLOOD PLAIN

Crop	No. of Acres	Usual Date for Production Practices				Date too late to Plant
		Land Preparation	Planting	Cultivating	Harvest	

1. What changes in land use have you made due to floods? ____________________

2. What changes would you make if the frequency of flooding were reduced by half? ____________________

3. How often do large floods occur? (If the flood described above is a large flood, change this question to small floods.) ____________________

4. During what seasons are floods most common? ____________________

5. In addition to the loss in yield described above, was there any damage to quality of crops? ____________________

6. What damage did this flood do to roads and bridges nearby? ____________________

Use other side for REMARKS.

<u>Agriculture Flood Damage Questionnaire</u>

Instructions

The purpose of this questionnaire is to obtain information from landowners and operators to be used with other data in the evaluation of watershed problems and needs and project effects.

List the name of the person being interviewed, the location of the farm or ranch and the name of the watershed under study.

Give the month and the year of a flood the respondent can remember. Show his estimate of the number of acres on this farm or ranch that were flooded by that flood.

Show the land use by acres of the acres flooded when that flood occurred. Show the maximum depth of that flood and length of time flooding occurred. Show the expected yield for each land use if no flood had occurred, and the yield after the flood. If the yield after the flood was caused by delayed planting from a prior flood, indicate with a star. Name the alternate crop and yield if applicable. List the additional production practices made necessary by the flood occurrence. List the production practices that did not need to be performed due to crop loss by flood. Use remarks section for additional space if needed.

List the other agricultural property by types damaged by that flood. Show the quantity flooded by depths of flooding. Show the respondent's estimate of damage for each depth, type or item and indicate which is the reference.

List the respondent's estimate of land damages.

List the normal land use of the total flood plain.

List the dates the farmer performs the indicated production practices when flooding is not a problem.

SCS-WS-6
6-72
FILE CODE WS-14

FORM APPROVED
OMB NO. 40-R3804
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DRAINAGE QUESTIONNAIRE

Respondent ________________ Farm Location ________ Reach ______

Years on Farm ________________ Size of Farm ________________

Watershed ________________ Interviewer ________________ Date ______

Problem Area Land Use

Future Production Without Drainage			Future Production With Drainage			Remarks
Crop	Acres	Yield/Acre	Crop	Acres	Yield/Acre	

1. What are your drainage problems? ________________
2. How often are you unable to plant a crop due to lack of adequate drainage? ________
3. How often do you need to make a separate planting due to lack of adequate drainage? ____
4. How often are you unable to harvest a crop due to lack of adequate drainage? ________
5. How much lime do you spread on problem area? ________________
6. Would you use a different type and rate of fertilizer with adequate drainage? Yes ☐ No ☐
7. If yes, what changes would you make? ________________

Remarks: ________________

V. CROP PRICES AND PRODUCTION COSTS

A. Crop prices.

1. The NED manual states that prices issued by the WRC (Current Normalized Prices) will be used to evaluate NED agricultural benefits. Adjustments may be made to reflect quality changes caused by floods or droughts. For other crops (CNP's not published), state average prices over the three previous years will be used.

2. a. Historically, there have been some problems with the use of these CNP's. First, the latest prices used in five-year weighted average are more than a year old when they are used in an analysis. Also, the prices used in the five-year average are not in constant dollars. The use of a CNP based on a weighted average of the season average price (in historical dollars) for a five-year period in a crop budget with production costs based on current market analysis does not meet the criteria of all economic analyses being based on current real prices.

b. These problems have been recognized for several years and correspondence between OCE and LMVD concerning this problem has been ongoing since February 1980. In July 1980, OCE met with USDA to discuss the problems with the CNP's. USDA agreed that these problems should be addressed and solutions sought.

c. In June 1981, LMVD developed a methodology for revising CNP's to make them compatible with other price levels being used in project analysis. Current normalized prices were calculated using current (constant dollars) while continuing to correct for the effects of short-term abnormalities by the use of a normalizing procedure. This was accomplished by putting the actual season average prices over the five-year period in current dollars using the implicit price deflator for total GNP. Revised Current Normalized Prices (in current dollars) were calculated as weighted averages of the average season prices (in current dollars) over the five-year period.

d. In July 1981, LMVD recommended that each of our Districts use the methodology discussed above to revise CNP's for respective states and to use these revised CNP's in the evaluation of all agricultural studies and in FY 84 budget submissions.

e. Recently received explanation of the computational procedures used by USDA to compute CNP's for FY 83 indicate that the procedure described above has been adopted by USDA. Explanation of this procedure reads in part:

(1) The season average prices for the base period (1977-81) are deflated by the implicit price deflator for the Gross National Product (GNP) into constant (1967) dollars. Other deflators (such as the Index of Prices Received by Farmers) were deemed unsuitable because they confound inflationary adjustments with short-term changes in prices due to market forces. The weights....................are used to derive a weighted average of the 1977-81 "real" price, i.e., a normalized price expressed in 1967 dollars.

(2) The weighted average "real" price is then multiplied by the implicit price deflator for the second quarter of 1982 in order to express the planning price in "current" 1982 values.

f. Examination of the table which shows the five-year season average prices and the CNP's indicates that the season average prices were converted to 1982 dollars before they were averaged, rather than as described above. Regardless of which procedure is used, the results will be the same.

g. Current normalized prices to be used in FY 83 will be expressed in terms of the general price level in the economy as of the end of the Second Quarter of 1982.

B. Production costs.

1. Production costs should be analyzed and crop budgets prepared. All costs will be included:

a. Costs of equipment ownership and operation;

b. Production materials;

c. Labor and management;

d. System Operation, Maintenance, and Replacement (OM&R); and

e. Interest payments.

2. The quantification of production costs follow:

a. Purchased inputs will be valued at current marked priced (i.e., for FY 83 should be based on general price level as of end of Second Quarter 1982 to be compatible with CNP's).

b. Labor (operator, family, or hired) costs will be based on the prevailing farm labor rates.

c. Management will be valued at 10 percent of the variable production cost (excluding the cost of land and capital improvements).

d. Interest on operating capital shall be calculated at project discount rate.

VI. INUNDATION REDUCTION - AGRICULTURAL CROPS

A. Damage Function/Calculations

1. The NED Manual states that one will develop periodic flood damage factors for the intervals that match the hydrologic data. It further states that historical flood damage information should be gathered through interviews with flood plain farmers and damage factors developed from these data. If unsufficient data are available in a given project area to develop adequate damage factors, proxy values may be generated by using crop budgeting.

Techniques. Since sufficient historical data are not usually available, the remainder of this discussion will deal with synthesizing damages to agricultural crops using budgeting techniques and hydrologic period-of-record data.

2. Calculate flood damages for each crop based on the without project crop distributions, yields, and budgets and the characteristics of flooding over a historical period-of-record. A composite acre (a mix of various crops within a given flood plain reach expressed in percentages) may be used in determining flood damages to crops; if this approach is used, the flood plain should be stratified for zones having a significantly different mix of crops, yields, production practices, etc. Cropping patterns, yields, etc., must reflect conditions in the flood plain in years in which no flood occurs.

3. One computer model available for crop damage analysis will be presented later in this discussion. The output of this model (Computerized Agricultural Crop Flood Damage Assessment System ... CACFDAS) includes damages by crop for all floods in the period-of-record and the total crop damages per peak acre flooded.

4. The next step in damage calculations is to determine average annual damages.

a. Determine average annual cleared acres flooded through integration of elevation-area flooded and elevation-frequency curves and computation of the area under the resulting *area flooded-frequency curve.* Partial duration-frequency curves should be used in this step of the analysis. Partial duration-frequency curves are based on all events above a selected base value (i.e., elevation at which flooding of cleared land begins) whereas annual frequency curves are based on the largest flood each year. Since in agricultural crop damage evaluation, seasonality is critical and recurrent flooding must be accounted for in the analysis, partial duration-frequency curves must be used.

b. Determine average annual damages by multiplying average annual acres flooded times crop damage per peak acre flooded. Average annual damages may also be determined by dividing total crop damages from all floods during the historical period-of-record by the number of years of record. The longer the period-of-record, the closer the results of these two methods should be.

B. Essential Information for Crop Damage Determination

1. Cropping patterns, yields, and budgets. As discussed earlier, this information must be based on years in which there were no floods (i.e., flood-free) and must be stratified for reaches of flood plain where there is significant difference.

2. Historical Period-Of-Record Hydrologic Data. Historical period-of-record hydrologic data are required to determine following flood characteristics:

a. Time of Year. Time of year (i.e., seasonality) of flooding is critical to accurate estimates of crop damages. For instance, a flood lasting

for 15 days in January would cause no damage to soybeans, whereas a flood in August of the same duration would destroy the crop on those acres flooded.

b. Duration of Flooding. Duration of flooding is also very important to crop damage estimates. Unless floodwaters have a high velocity, floods of short duration such as one or two days will probably cause very little damage.

c. Recurrent Flooding. Determination of whether flooding has occurred previously during the year and whether or not it was a damaging flood is also critical to crop damage estimates. For instance, a flood occurring in September on soybean land would cause no damage if a flood in August had already destroyed the crop. A flood occurring in July on land that was initially in corn, but had been replanted in soybeans because of a previous flood in May would not cause the same amount of damage as it would if it were the first flood of the year.

d. Elevation of Flood. The elevation of the flood determines how many acres will be flooded and therefore how much damage is incurred.

3. Frequency Curves. Frequency curves are required to determine probability of flooding and average annual acres flooded. As discussed earlier, partial duration-frequency curves should be used.

4. Stage-Area Curves. Stage- or elevation-area curves are required to determine acres of cropland flooded for given elevations. Stage-area curves are integrated with stage-frequency curves to obtain area-frequency curves. The area under this integrated curve is the average (or expected) annual acres flooded.

C. Model or method for determining damages.

1. One model that is available for determining flood damages to agricultural crops and is being used in the four Districts in LMVD and by several Districts outside LMVD is the Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS). CACFDAS utilizes historical flood data on daily basis, current budget data, present cropping patterns and production techniques including crop replanting and substitution, as well as other relevant data to assess damages to crops.

2. Outputs from CACFDAS include acres flooded over the historical period, total damage by crop, and damage per acre flooded.

3. CACFDAS is a very flexible tool and is easily adopted to changing conditions in various areas of the country.

VII. INUNDATION REDUCTION - OTHER AGRICULTURAL PROPERTIES

A. The term "other agricultural properties" includes physical flood plain improvements associated with various farm enterprises and the agricultural community such as rural residential, commercial, and industrial; barns, equipment sheds, and grain bins; fences, drainage ditches, and roads and bridges; equipment, etc.

B. Steps in determining damage to other agricultural properties.

1. Inventory Damageable Flood Plain Improvements. Identify the location, type, number, and value of other properties. In the case of properties such as rural residential, commercial, and industrial, the value of contents, construction type, and first floor elevation should also be determined.

2. Determine Damages to Flood Plain Improvements. The determination of damages to flood plain improvements will be based on historical data and/or simulation. Some methods of determining this are:

a. Interviews with flood plain residents, farmers, etc.;

b. Field reconnaissance; and

c. Simulation based on structure type, elevation, and value; elevation of various frequency floods; and depth-damage relationships.

3. Determine Average Annual Damages. This is accomplished through integration of elevation-damage relationships with elevation-frequency data.

C. Seasonal occurrence of flooding is generally not considered important and adjustments are not made for recurrent flooding in a given year. Annual frequency curves are generally sufficient for this analysis.

D. Level of detail, especially in the inventory phase, may vary considerably depending on the importance (i.e., relative magnitude) of the benefit category to the evaluation.

VIII. INTENSIFICATION

A. Intensification benefits are the value of a plan to activities which are thus enabled to utilize their land more intensively and thus increase net income. An example would be a shift from lower to higher value crops (i.e., soybeans to rice) and/or higher crop yields. Intensificaiton benefits can also result from project-induced reductions in production costs.

B. The following discussion identifies steps to be followed in the reevaluation of intensification benefits:

1. Determine the frequency of flooding at which flood risk ceases to influence farmers' decisions on type crops, production practices, etc. This will be based on knowledge of the study area and on interviews with farmers and other agricultureal experts. The elevation of this flood frequency will be used as one zone of stratification.

2. Current and projected flood-free land use (cleared, wooded, other) and cropping patterns will be identified for all stratified segments of the flood plain for both without and with project conditions based on the same sources (i.e., interviews, etc.) as discussed above. Flood plain stratification will be based on the frequency of flooding developed above as well as other factors which would cause significantly cropping patterns, yields, and/or production practices.

3. Current and projected flood-free yields will be developed for the stratified segments of the flood plain for both with and without project conditions. Increases in yields due to future improvements in technology shall not be included in the evaluation of intensification benefits.

4. Detailed, crop specific, production budgets will be developed for each flood plain stratification for with and without project conditions.

5. Differences in net income without and with project will be determined for each stratified segment of the flood plain for each selected time period. Some of the factors causing these differences in net income may be:

a. Farmers' decisions because of reduction in flood risk.

(1) Changes in cropping patterns (i.e,, shifting from lower to higher value crops).

(2) Increased production inputs (e.g., additional fertilizer could increase yield levels).

(3) More effective planning and timing of operations.

(4) Increased land leveling. This might provide better drainage and increase yields. It might reduce production costs by increasing efficiency of equipment.

(5) Construction of additional drainage works. Reduced flooding, improved outlets, etc., might induce farmer to construct additional onfarm drainage which would lead to increased yields.

(6) Reduced production costs. Production costs could be reduced by increased equipment efficiency, reduced cultivation requirements, etc., because of project.

b. Yield responses without changes in production practices. These increased yields might be realized because of increased efficiency of existing drainage works due to project providing a better outlet, etc.

6. Benefits will be the difference in net income with and without for current acreage of all crops and/or increased acreage of basic crops. Benefits will be reduced by the increase in remaining damages because of the

more intensive use. The ten (10) basic crops are: rice, corn, wheat, cotton, pasture, hay, soybeans, milo, oats, and barley.

7. Benefits for increased acreage of other crops will be the efficiency gained in the project area compared to typical lands in the WRC Assessment Subarea (ASA).

a. Identify cropland areas in which increased acreages of other crops will occur due to project measures. The proportion of these crops in the project areas shall not exceed their proportion in the protected areas of the ASA. The NED benefit is the difference between the cost of producing the output in the project area, and the cost of producing the same output on the protected areas elsewhere in the ASA.

(1) Identify the characteristics such as length of growing season, quantity and quality of water available, soil fertility, etc., that are superior to those in other areas of the ASA producing the crop on which benefits are being claimed.

(2) Determine the projected increased acreage and production of the crop in the project area.

(3) Determine the cost of producing the crop in the project area.

(4) Identify, within the same ASA as the project, an area in which significant acreage of the crop is currently being grown and whose yield represents the average in the ASA.

(5) Determine the cost of producing the same volume of the crop in the area selected in the above paragraph (protected area of ASA).

(6) Determine the net income in the area selected above (protected area of ASA) if the cropping pattern shifted to some composite of the ten basic crops.

(7) Calculate the benefits as the difference in producing the crop in the project area versus the selected area in the ASA plus the difference in net income in the selected area of the ASA with the composite of the ten basic crops and in the project area without the project.

b. Benefits must be adjusted by remaining flood damages.

IX. PROPOSED P&G REVISIONS TO NED MANUAL - AGRICULTURAL FLOOD CONTROL

A. The procedures presented in the preceding discussion are in accordance with the Principles, Standards, and Procedures. On 9 September 1982, WRC met and agreed to repeal the Principles, Standards, and Procedures and replace them with the Principles and Guidelines (P&G). Upon approval of the P&G by the President, a notice of action will be placed in the Federal Register. Repeal will be effective 120 days after the notice is published.

B. The P&G has made some significant changes in NED evaluation of agricultural projects. The P&G is relatively vague in procedures to be followed

and field offices have not had time to tailor current methods and/or develop new ones that are compatible with the P&G.

C. Some of the changes in procedures for evaluation of agricultural projects include:

1. Provision of a test to determine if another crop may be evaluated as one of the basic crops. Basically, if a determination is made that the production of other crops (other than 10 basic crops) is limited by the availability of suitable land, these crops may be treated as basic crops when measuring intensification benefits.

2. Change in the definitions of the benefit categories. The P&G states that agricultural benefits are divided into two mutually exclusive categories, depending on whether there is a change in cropping pattern.

(a) Damage reduction benefits. Benefits that accrue on lands where there is no change in cropping pattern between the with and without project conditions.

(b) Intensification benefits. Benefits that accrue on lands where there is a change in cropping patterns.

3. Consistent treatment of benefits from technological changes by allowing them to be counted in all appropriate cases. P&G states that increases in yields due to future improvements in technology may be included for both benefit categories when realization of these yield increases are dependent upon installation of the project.

4. Changes the basis of management costs in production cost. P&G states that management cost will be estimated on the basis of type of farming operation. Normally, at least six percent of variable production cost. P&S said 10 percent.

5. Provision of an alternate procedure based on changes in market value of land for use in estimating intensification benefits.

D. Problems with agriculture evaluation as described in P&G.

1. In many instances, P&G is very vague. For instance, the Corps has always used flood-free concept when dealing with yields, cropping patterns, etc. This allowed for the separation of flood damage reduction benefits and intensification benefits without double-counting.

2. If we do not use the flood-free concept, but go to average yields, etc., the information possibly could be biased by recent weather cycles (i.e., a dry cycle, no flooding, or a wet cycle more than normal flooding).

3. The mutually exclusive definitions seem to be very misleading. Intensification often occurs on lands where no cropping pattern change are present. The farmer intensifies his operation and increases yields because of the project without changing cropping patterns. On the other hand, there are damage reduction benefits on lands where cropping patterns change because of the project.

4. Efficiency benefits are defined as the difference between the cost of producing the other crops in the project area and the cost of producing them on other lands in the ASA plus the net income that would accrue from production of an appropriate mix of basic crops on those other lands. This seems to be in error; the latter component of the benefit should be the difference in the net income that would accrue from production of an appropriate mix of basic crops on those other lands and the net income in the project area without the project.

COMPUTERIZED AGRICULTURAL CROP FLOOD DAMAGE ASSESSMENT SYSTEM

ECONOMIC AND SOCIAL
ANALYSIS WORKSHOP

ST. LOUIS, MO
25-29 OCTOBER 1982

Robert L. Burke
Regional Economist
Vicksburg District

COMPUTERIZED AGRICULTURAL CROP
FLOOD DAMAGE ASSESSMENT SYSTEM

1. Vicksburg District's major objective in designing this program was to develop a computerized procedure to quantify agricultural crop flood losses.

2. The CACFDAS utilizes initial crop distributions, computerized crop budget data, subsitution of alternative crops, damage duration data, and daily historic hydrologic data to compute flood or inundation damage estimates to crop. The program utiilzes historic gauge readings from the time of gauge installation to the present. Analysis of these data results in output of estimated damages based on current technology, yields, and price levels.

3. The program utilizes daily flood events in computing flood damages for each individual crop. This gives the program sensitivity in dealing with different dryout periods for lands at different elevations within a flooded area. The program will handle multiple floods in any year, and allows for specific crop replanting and/or crop substitution.

4. There are three major factors affecting crop losses. These are time of year that flooding occurs, flood depth, and length of time that a particular crop is actually flooded.

5. In order to determine the effects of crop flooding at different stages of plant development, the growth cycle was divided into four stages. Stage I is from planting to germination. Stage II is from emerging plant to the five-leaf stage. Stage III is from five-leaf to blooming, and Stage IV is from blooming through harvest. The following table shows the duration in days that causes damage for different crops at the four stages of development.

FLOOD DURATION IN DAYS THAT RESULTS IN LOSS

Crop	Damage by Stage of Plant Development			
	I	II	III	IV
Cotton	2	2	2	2
Soybeans	3	2	4	4
Wheat	4	2	2	2
Corn	3	4	5	7
Grain Sorghum	3	4	5	6

6. Crop losses are expressed in three ways. The first is increased production costs that arise from replanting crops or repeating field operations after a flood event. The second is crop yield reductions. Research has shown that planting dates have a significant impact on yield levels. For example, research at Mississippi State University has shown that the optimum planting dates for cotton are from about 30 April through about 15 May. Plantings after 15 May will result in significant yield reductions in a "normal" year. The same relationship of yields to planting dates is true for all other crops. The third way in which crop losses are expressed is reduced net returns. Reduced net returns result from a combination of increased production costs and decreased yields.

7. As with any simulation model, some assumptions must be made. For the CACFDAS these assumptions are (1) the availability of up-to-date crop budgets that include all costs of production, (2) crop distributions and yields for each crop are known. With this yield and crop distribution data, current prices can be applied to determine gross revenues. Revenues from crops are assumed to be the only source of income. Net returns are then calculated as the difference in gross revenues and total production costs.

8. The following table illustrates a budget for soybeans typical management. The budget contains sequential field operations and the associated cost of each operation. Also shown are expected yield, product price, and gross and net revenues.

ESTIMATED COST AND NET RETURNS PER ACRE
(Soybeans, Typical Management Practices)

Item	Unit	Price ($)	Quantity	Amount
Income				
Soybeans	bu	6.19	25.00	154.75
Total Income				154.75
Direct Expenses				
Common Labor	ltr	2.65	0.14	0.37
Operator Labor	ltr	2.65	1.69	4.48
Special Labor	ltr	2.65	0.23	0.61
Treflan	lb	5.85	1.00	5.85
Seed	lb	0.17	66.00	11.22
Dyanap	pt	0.90	4.00	3.60
Apply Herbicide-Air	ac	1.65	1.00	1.65
Dinitro	lb	2.28	0.60	1.37
Haul	bu	0.03	25.00	0.85
Special Equipment	ac	4.00	1.00	4.00
Equipment	ac	3.34	1.00	3.34
Tractor	ac	6.47	1.00	6.47
Interest on Capital	ac	1.78	1.00	1.78
Total Direct Expenses				45.59
Net Returns Above Direct Expenses				109.26
Fixed Expenses				
Special Equipment		6.19	1.00	6.19
Equipment		6.50	1.00	6.50
Tractor		8.82	1.00	8.82
Total Fixed Expenses				21.51
Total Specified Expenses				67.10
Net Returns Above Specified Expenses				87.65

9. The following illustrates the format used to input budget data and other specific crop data such as calendar date and Julian date for each field operation, expected gross revenue by harvest period, and duration in days that cause crop damage. The example used is for soybeans typical management.

FLOOD DAMAGE TABLE
SOYBEANS TYPICAL MANAGEMENT
Expected Net Returns: $ 87.65
Gross Returns: $154.75
Production Cost: $ 67.10

Operation	Date	Day Number	Operation Cost	Operation Revenue	Duration Resulting in Flood Damage
			($)	($)	(days)
Fixed Harvest Cost	1 Jan	1	6.19		0
Disk Harrow (twice)	20 Mar	79	5.54		0
Disk & Incorporate (twice)	5 Apr	95	9.56		0
Field Cultivate (twice)	17 Apr	107	3.82		0
Row Condition	1 May	121	3.15		0
Plant (inc. trailer)	14 May	134	15.05		3
Apply Herbicide-Air	1 Jun	152	5.25		2
Cultivate Early	5 Jun	156	3.10		4
Cultivate Late	19 Jun	170	2.06		4
Cultivate & Post (late)	30 Jun	181	4.09		4
Cultivate Late	17 Jul				
Interest on Operating Capital	17 Jul	198	3.84		4
Combine & Haul 1st Period	6 Oct	279	1.53	43.33	4
Combine & Haul 2nd Period	21 Oct	294	1.15	32.50	4
Combine & Haul 3rd Period	4 Nov	308	1.26	35.59	4
Combine & Haul 4th Period	18 Nov	332	1.20	34.05	4
Combine & Haul 5th Period	2 Dec	336	0.32	9.28	4

Harvest Rate: 1st Period: 28 percent; 2nd Period: 21 percent; 3rd Period: 23 percent; 4th Period: 22 percent; 5th Period: 6 percent

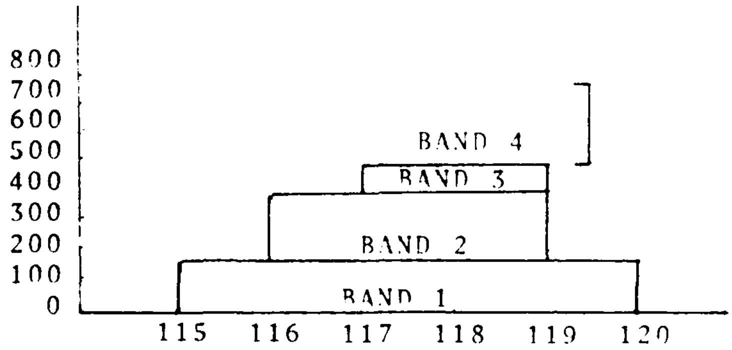
10. In addition to the budget data discussed in the preceding paragraphs, data on the initial crop distribution, alternative crops, planting dates for initial crops and replant crops, dryout periods, and the flood history must be input to the program. The initial crop distribution is that set of crops that are assumed to be in place during the first flood of the flood year. Alternative crop data provide information that allows the program to replant the initial crop or substitute another crop when flooding has destroyed an initial crop, or flooding conditions extend past the normal or usual planting date for the initial crop. Planting dates for initial crops are the assumed normal planting dates and usually coincide with the optimum planting date for each crop. Last date for crop replant sets the time limit on replanting crops, because a crop planted after this date is assumed to have insufficient time to reach maturity in a normal growing season. The dryout period consists of the number of days necessary for the soil to dry sufficiently to allow field operations. The flood history consists of daily gauge readings that show stages and acres inundated on that date.

11. The following paragraphs contain an example of one flood event on a given area. The area is assumed to have an initial crop distribution of 45 percent cotton, and 45 percent soybeans. This initial crop is usually determined by field surveys or other methods. Gross revenue and net revenue for cotton are \$444.44 and \$147.10, respectively. Gross and net revenues for soybeans are \$154.75 and \$87.65, respectively.

12. Figure 1 below shows the starting and ending date for this flood and the acres inundated on each day during the flood. This illustration also shows

how the program divides the flood into bands of inundation. A band is simply the area over which the flood level increased or decreased over a 1-day period, based on the historic flood data.

FIGURE 1



13. The purpose of banding is to account for different dryout periods associated with different elevations within a flooded area.

14. An analysis of Band 1 indicates that a total of 150 acres was flooded for 5 days. Based on the assumed initial crop distribution, this means that 67.5 acres each of cotton and soybeans were flooded. Operation damages for cotton were $6,561.00 (67.5 x $97.20). The $97.20 value is the total of operational expenses for cotton through planting and comes from a budget for cotton typical management (shown below). Also, note that the critical duration for cotton typical management on day 115 is 1. Net revenue damages for cotton were $9,929.95 (67.5 x $147.10). The value $147.10 is the net revenue for cotton.

FLOOD DAMAGE TABLE
COTTON TYPICAL MANAGEMENT
Expected Net Return: $147.10
Gross Returns: $444.44
Production Costs: $297.34

Operation	Date	Day Number	Operation Cost	Operation Revenue	Duration Resulting in Flood Damage
			($)	($)	(days)
Fixed Harvest Costs					
Picker	1 Jan	1	39.17		0
Stalk Shredder	2 Jan	2	3.88		0
Chisel Plow (twice)	1 Mar	60	6.28		0
Disk & Incorporate	13 Mar	72	6.63		0
Disk Harrow	20 Mar	79	2.77	97.20	0
Field Cultivate	27 Mar	86	1.91		0
Disk Bed	1 Apr	91	2.08		0
Disk Bed & Fertilizer	5 Apr	95	11.22		0
Row Condition	10 Apr	100	3.15		0
Plant & Pre (inc. trailer)	25 Apr	115	20.11		1

15. Although 67.5 acres of soybeans were flooded, no damages resulted from this flooding. This is because the critical duration for soybeans typical management is 0 until day 134 (see Flood Damage Table, Soybeans Typical Management, presented earlier).

16. Total damages for Band 1 are $16,490.25 ($6,561.00 + $9,929.25).

17. Band 2 had a total area of 250 acres flooded. This means that 112.5 acres each of cotton and soybeans were flooded. Damages to soybeans are still $0. Damages to cotton were $10,935.00 in operational damages and $16,548.75 in net revenue damages. This is a total for Band 2 of $27,483.75.

18. Band 3 had a total area of 100 acres flooded. With the assumed crop distribution, 45 acres each of cotton and soybeans were flooded. Soybeans still had no damages. Operational damages for cotton were $4,374.00, and net revenue damages were $6,619.50. This was a total of $10,993.50 for Band 3.

19. Band 4 had a total area of 300 acres inundated. This area was inundated for only 1 day, but for day 118 the critical duration for cotton typical management is 1 day. Based on the crop distribution there were 135 acres each of cotton and soybeans flooded. Soybeans still experienced no damage. Operational damages for cotton were $13,122.00 and net revenue damages were $19,858.50. This was a total of $32,980.50 for Band 4.

20. The program will provide damage totals by band and a total for the entire flood. Total damages from this flood were $87.948.00.

21. After all the damages have been calculated for the flood, the program determines how the crop distribution changes due to the destruction of 360 acres of cotton. To determine whether the cotton can be replanted or another crop should be substituted, the program checks the last date for replant for cotton. The last date for replant is day 145. The flood ended on day 120, so with 10 days for dryout, there is still time to replant all the damaged acres to cotton. The crop distribution of the area would remain the same, except that 360 acres of the cotton would be cotton replant which would experience yield reductions due to the later planting date.

22. The program has three levels of report output that can be utilized. The brief mode reports damages per flood year and summaries for each reach. The normal mode outputs damages for each flood, for each year, and for each reach

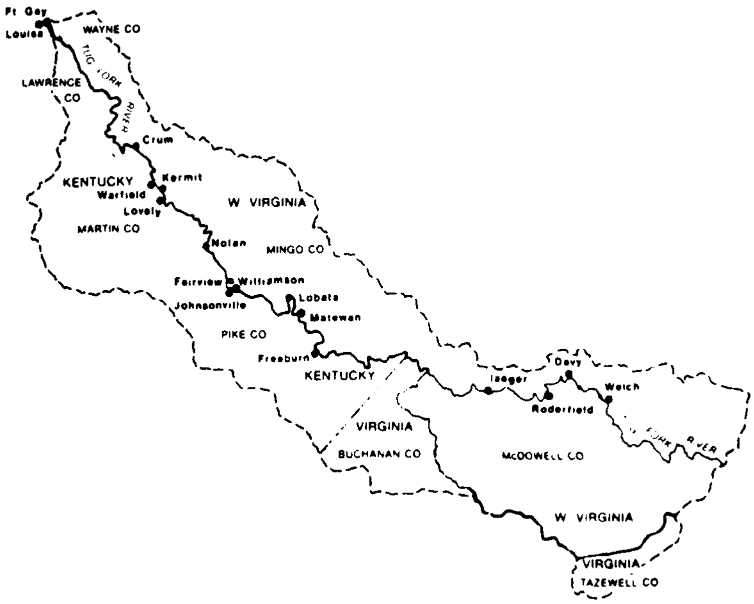
being analyzed. The debug mode gives very detailed information including all the reports in the normal mode plus data down to the band level within each flood.

23. Data changes required to modify the program for use in other geographic areas are straightforward. Data required are (1) crop distribution data, (2) crop budgets for specific crops, (3) crop substitution sequence, (4) last date for replanting activities, (5) crop flood damage-duration data, and (6) digitized stage-area data. Area agricultural universities should be able to provide these date.

HUMAN COSTS ASSESSMENT -

THE IMPACTS OF FLOODING & NONSTRUCTURAL SOLUTIONS

TUG FORK VALLEY WEST VIRGINIA & KENTUCKY



EXECUTIVE SUMMARY

U.S. ARMY ENGINEER INSTITUTE FOR WATER RESOURCES
KINGMAN BUILDING
FORT BELVOIR VIRGINIA 22060

APRIL 1980

EXECUTIVE SUMMARY

CONTENTS

Human Costs of Flooding in the Tug Fork Valley

T. Background: Flooding in Central Appalachia

The Williamson Daily News headline of 5 Mar 79, "Tug Fork Problem May be the Worst in U.S.", summarizes a complex reality. Central Appalachia represents a large share of the nations coal resources, it is founded on the geological results of the Pleistocine age, subsequent upheaval of the earth's surface and consequent erosion. Harry Caudill describes the landscape as "wrinkled. . .intricately comparted, affording isolation for decades and the illusion of isolation for more than a century."[1] Hills with about 1,000 feet of relief, sharply dissected and characterized by alternating layers of limestone, sandstone, shale and coal, support an economy founded on coal, timber and marginal agriculture. The same hills offer fundamentally poor foundation conditions, so building is essentially limited to valleys or hilltops. When the Central Appalachian area went through its most rapid settlement and development period (late 19th Century and early 20th Century) with the coming of railroads and paved highways, the settlement and development pattern clung to the protected valleys. Highway and rail beds are in the valleys.

Overlay this wrinkled landscape with a human landscape founded by Scotch-Irish and English settlers, who were looking for isolation, estranged from organized society, mostly Protestant and white. Caudill writes of sustained migration into the Kentucky mountain wilderness following the Revolutionary War until about 1812 when the flow declined.[2] Subsequently, waves of development beginning in the late 19th Century to harvest timber and coal were facilitated by the coming of the railroads and the buildup of the nation's industrial sinews. Rail, coal and timber are capital intensive industries, requiring management, capital access and organization far removed from the isolated independent character of the human landscape. Ownership, control and management were vested in the corporate structure required to facilitate capital intensive technology. This control extends to surface and mineral rights, resulting in mostly outside ownership of the land and to the political and economic power of interests far removed from Central Appalachia.[3] These trends are visible in every part of the American economy from agriculture to health services as the logical institutional outcome of capital intensive technology. Therefore, they are only repeated here to help describe these influences in an unexpected corner of human experience.

------

1. Harry Caudill Night Comes to the Cumberlands, Atlantic--Little Brown Books, 1963 p. 19.
2. Caudill, p. 10.
3. See John Fetterman, Stinking Creek, Dutton Paperback (1970), for an intimate description of a small mountain community in Appalachia, and Rebecca Caudill, My Appalachia, for a personal reminiscence. Miss Caudill writes of "her childhood, when the snow was clean, before the mines came, before the bitterness and bloodshed began, when poverty was a book word, when poor didn't know they were poor and in Appalachia pride and dignity filled a half empty stomach."

Settlement in the valleys, ownership of land by outside interests and the wrinkled landscape combine to form a peculiarly difficult set of problems resulting from a natural component of the hydrologic cycle. Water evaporates to the atmosphere and returns as rain. Rainfall varies from gentle showers to raging downpours. After a raging downpour Central Appalachia suffers floods. If the people were not there, if the coal and timber were not there, if the railroad and highways were not there, and if cities and villages and strip settlements were not there, periodic floods would only affect the ecology of Appalachia. Because all of these are there floods bring havoc, suffering and heavy damages.

One way out would be to declare that all development and habitation relocate to flood free sites. Another is to contain and control floods. Both solutions entail heavy costs and difficult problems of implementation. Even worse, the "do nothing" choice, entails even more difficult and intractible costs. The coal, timber and other natural resources of Central Appalachia fuel America's economic process. The nation has, however, successfully obtained the benefits of these resources without paying the whole bill. A result is that Central Appalachia contains a disproportionate number of the nation's defeated people, a scarred landscape, piled with refuse, an expensive and mounting bill of flood losses, a festering conflict between management and labor and between the haves' and have nots, a miserable level of housing and therefore lower capability to meet the nation's pressing energy needs.

Flood containment and control brings additional problems, if reservoirs are sought, due to heavy relocation costs (people, homes, transportation routes and other inpristructures) and displacement of access to coal reserves. Other structural solutions (flood walls, flood proofing buildings by sealing and elevation) bring not only costs due to construction, but potentially serious difficulties resulting from flood events which exceed the design criteria.

A response to the flooding problem then entails a sophisticated requirement for design and implementation. The research reported here, undertaken by the Institute of Water Resources and several contractors attempts to add an assessment of the human costs due to flooding in the Tug Fork Valley of Central Appalachia, an assessment of potential impacts if voluntary relocation is undertaken, and finally, an assessment of the social nature of the communities which are affected by floods and from which flooded residents might voluntarily relocate.

The 1977 Flood

In the time of year when the redbuds and dogwoods are blooming, and the leaves unfolding to canopy this wrinkled landscape, on April 4, 1977, 45 counties in four Appalachian States were struck by flooding. These 45 counties produced over 162 million tons of coal in 1974, reporting 54.7 percent of production of the four states and 41 percent of coal production in the Appalachian region. The 45 counties contained a population of 1.47 million people and this population is increasing due to expanded coal production.

Of the 45 county disaster area, the Tug Fork Valley suffered the most serious impacts. Within 30 hours, up to 15 inches of rain were dumped by a series of cloud bursts on frozen ground near the headwaters of Tug Fork. As the deluge moved down the valley flood crests exceeded known records. Williamson West Virginia had a flood crest of 52.3 feet, more than 25 feet above flood stage. Flood losses exceeded $100 million in Mingo County, an amount larger than the total personal income earned by Mingo County residents in the entire year of 1973. Total losses in Tug Fork Basin approached $200 million.

Tug Fork is located within 7 counties of West Virginia and Kentucky. Coal is king in the the Tug Fork Valley. Daily, 16 unit trains laden with coal exit the valley moving north, west, and east. Thirty thousand people reside in the valley and 10,000 live in the flooded area. Over 100 communities or places (none over 4,000 population) are scattered in a linear fashion along the Tug River.

Previous Attempts to Alleviate Flooding

A large regional flood in 1957 brought survey studies by the Corps in the Upper Kentucky, Upper Cumberland, Upper Lilky, Big Sandy and Tug Fork Basins. A reservoir system was authorized and subsequently constructed in the Big Sandy Basin. A major cut off project is under construction to alleviate flooding in Pineville, Kentucky, and to provide a new transportation corridor and to facilitate community renewal. The project is managed by the Kentucky Department of Highways with Corps of Engineers and other agency participation. In the Tug Fork, local protection by flood walls was installed at Williamson in 1963 and later for the Appalachian Regional Hospital in West Williamson. Reservoir sites were found to entail very heavy costs, difficult implementation, and limited effectiveness in the Tug Fork, and therefore, none have been constructed. A path-breaking analysis of non-structural flood damage reduction management (through flood proofing by elevation of existing structures in Matewan) was conducted by Huntington in 1970. Meanwhile, the Tug Fork Basin has experienced four major floods since the 1957 event climaxing with the April 1977 flood. That flood topped the flood wall at Williamson by several feet and created the disaster that not only resulted in $200 million in damages but also a $150 million disaster recovery program primarily financed by the Federal government. With the exception of about 60 homes which were completely destroyed by the flood, the disaster recovery operation fundamentally placed people back in the same situation that they were in before the 1977 flood. The Appalachian Regional Commission has moved to implement a region-wide flood warning and evacuation system, which will serve to reduce the threat of flooding to loss of human life and can partially reduce flood damages.

The IWR Study

The Huntington District was engaged in a restudy of the Tug Fork flooding problems when the 1977 flood occured. Following the flood recovery efforts, the District moved (by legislative directive) to develop a comprehensive solution to the flooding problems. That is, the solution should

be uniformly effective valleywide. A small part of that effort found its way to this study. IWR proposed to conduct a study with five major elements:

1. Human Cost of Flooding
2. Housing Analysis
3. Community Analysis
4. Social Profile
5. Evaluation of Impacts of Flooding on Coal Mining Productivity

The studies were conducted by IWR staff and through a contract with Cornell University. Economists and sociologists worked together to generate the data base and analysis which would satisfy study objectives. The purpose of this study was to develop a broader assessment of the human costs of flooding and to facilitate implementation of voluntary relocation. Both flooding and the solutions to flooding involve real economic, social, environmental, and political costs. The challenge is to find solutions which are rational, implementable, and practical.

II. Findings of the Human Resource Costs Approach

A. Quantifying Human Resource Damages

Three forms of human resource costs are documented as damages of flooding in this study. These costs involve impairment of individuals and households which reduces their capacity for productive participation in the economy. The impairment processes are: (1) phychological trauma, (2) attrition of household financial asset position which reduces financial capability and changes outlook, and (3) reduction in productivity of coal miners. The economic consequences of psychological trauma and reduced coal mining productivity are estimated. The process of household financial asset attrition and adjustment response behavior are quantitatively traced, but the economic loss is not estimated. This would have required substantial additional research which could not be fitted into this study frame.

1. Psychological Trauma

Responses to survey questions from people who were in the 1977 flood reflected twenty-two factors indicating the psychological impact of the flood. Adverse psychological impacts were then rated in terms of severity and were summed for each surveyed household. The scores, then arrayed into a three-level scale comparable to levels corresponding approximately to the American Medical Association three-level scale of psychological impairment, results in the following distribution:

Level I - 1 to 9 points (39% of households);
Level II - 10 to 12 points (32% of households);
Level III - 13 to 20 points (29% of households).

The assignment of household trauma score levels to individuals in those households was accomplished in the following way:

Level I - 84 households = 181 individuals;
Level II - 114 households = 369 individuals;
Level III - 80 households = 291 individuals.

The levels of psychological trauma measured in the survey of 1977 flood victims and matched to the three levels of AMA psychological impairment scale, were then set to corresponding Veterans' Administration disability compensation payments for comparable median percentages of impairment. The annual compensation values, multiplied by numbers of individuals at each trauma level of impairment, were as follows:

Level I - 181 individuals x 0 compensation = $0
Level II - 369 individuals x $1326.60/yr = $489,515.00/yr
Level III - 291 individuals x $4315.20/yr = $1,255,723.00/yr
Total Compensation = $1,745,238.00/yr

The 225 households of Levels II and III are representative (based on sample characteristics) of the 5300 residences actually damaged by the 1977 flood. The estimate of $1,745,000 per year for psychological damages averages $8,9[illegible] per household.

How long did the trauma effects persist at the levels measured? Indicators for the trauma scale were directed to any time or duration within the interval between the 1977 flood and the survey. Some of the effects reported by respondents lasted even less than the first year, and many people had recovered by the end of the second year. However, many effects were still active at the time of the survey, slightly over two years after the flood, and may continue indefinitely. The response to a question on "Back to Normal?" confirmed such continuing effects.

If the rates measured are applied strictly for two years (thus assuming that effects of shorter and longer duration cancel out) the total of $18,000 trauma costs per household is substantially larger than the approximate $9000 per residential structure of property damage incurred in the 1977 flood. Applying the $18,000 to the 5300 homes damaged or destroyed, there is a total psychological trauma damage amounting to $95,000,000. These losses exceed total residential property losses by about 50 percent, and compare with total property losses of 127 millions, business losses of 45 millions, and emergency/recovery costs of 26 millions.

Two alternative approaches to valuation give quite consistent results. They were developed independently of the above estimate. First, the approach used to allocate the Buffalo Creek out-of-court settlement for a flood caused by a dam failure was adapted to Tug Fork. The result for the 1977 flood was $93,000,000. Second, evaluation was made based upon a Life Event Social Readjustment rating scale and workers compensation awards which produced a range of estimates from 18 million dollars to 164 million dollars - midpoint 91 million dollars.

2. <u>Coal Productivity Loss</u>

The objectives of this study unit were to estimate the adverse impacts of flooding on coal mining productivity - that portion of the variation in coal produced per coal miner when other major sources of variation are accounted for. The direct disruption arising from physical damage to mines, equipment, and coal transport systems was included in property losses. Other more pervasive impacts on productivity stem from the long-run attrition in housing quality, diminishing availability of public services, and lowered quality of life. The productivity costs of the latter impacts alone are at issue here.

<u>Analysis</u>. The impact of flooding on coal mining productivity was evaluated by means of a regression model of productivity data from 43 Appalachain counties. Output per employee was compared with flood damages per capita for the record flood in each county and the percent of coal produced by surface mining. Productivity is much higher in surface mining than in deep mining. The model was calibrated from data for 43 Appalachian counties which produced at least one million tons in 1975 (an averaged 5.4 million tons. The following table shows the summary statistics.

Flood of Record Effects on Coal Production in 43 Appalachian Counties

	Tons Produced, '75	Employment	Tons/EMP	(PCSURF) % Surface Mining
Average	5,451,791	2,350	2,333	52.5
Standard Dev.	588,941	307	1,432	4.9

	1970 Pop. Affected by Flooding	*Damages from Record Event	(FLCAP) *Per Capita Damage of Record Flood
Average	7,653	$4,087,000	$ 534
Standard Dev.		$4,886,000	$1,255

*1975 Dollars

Two measures of association were attempted, both show modest relationships the proper direction.

Correlation Coefficients

Per Capita Flood Damage	- .18451		
Tons	- .25820	.23025	
% Surface	.50538	- .02738	- .48151
	Tons per Employee	Fl. Damage per Capita	Tons

One interesting thing about the data is that the largest coal produc counties show a negative correlation with productivity. Higher productiv is associated with the percent of surface mining and negatively correlated with flood damages per capita. Regression results are about as expected. per capita flood damage variable shows a coefficient of the correct sign w a modest degree of significance (a coefficient which rejects the null hypothesis at a .90 probability).

The regression format is as follows:

Tons per employee = f (annual tons produced, per capita flood damage from record event, and percent of coal produced from surface mining).

The statistically significant variables are abbreviated in the summary below:

	Average Value	Standard Dev.
TON/EMP = 1,926 - .002 (FLCAP) (1.4)	X_1 = \$534 FLCAP	1255
F = 3.97 + 2.1 (PCSURF) (3.0)	X_1 = 52% SURF	32

The regression using flood damage per capita shows a stronger statistical relationship than does regression on total flood damages and emphasizes a need to reduce the flood hazard in the most severely affected areas. The elasticity of the flood damage per capita coefficient is -.03639, indicating that a one percent reduction in flood damage per capita would result in a 3/100 percent increase in productivity per employee, or an average increase of 9 tons per employee, worth about \$20 a ton or \$180 per year. In the average county this would amount to \$428,000 additional product per year.

If these results are applied to the Tug Fork counties, the potential impact of flood damage reduction in improving coal mining productivity is 17,103 tons per year for each percent decrease in flood damages. Since the flood damage variable is based on the record flood, reduction of the 1977 flood by 75 percent would result in extra production of 1,282,725 tons per year worth an excess of \$25 million annually. Since this extra production can be achieved without additional inputs, the value of the product is a net increase in national output and income.

Conclusion. That much of the coal production loss estimated in this study is attributable to impairment of miners as a human capital resource is strongly suggested by arguments and results of both the study of trauma damage and the study on household disruption, which provide a context for this estimate.

The Tug Fork area has natural environment problems coupled with the "boom to bust" cycle of an extractive economy which have, together, led to a harmfully low level of living for its people. Although they contribute a fundamentally necessary and valuable resource which supports the standard of living of Americans elsewhere, citizens of this valley must live in communities that provide sub-standard public services (or none). Many of them also live in houses which fail to meet national standards of decent, safe and sanitary. One third of them live in locations at flood risk. Their ability to move is rigidly constrained by housing supply, topography, shortage of flood-free sites, unavailability of land, and their own low incomes.

Five severe floods in the last 20 years have been one of the major cumulative factors working on attrition in housing quality and quantity, in public facilities infrastructure (lost or not developed) and in the human resource capacity of labor and the population at large to participate productively in the economy toward self-maintenance and regional development.

The communities cannot fully recover from successive floods and maintain a high quality and variety of public services conducive to their own productivity unless State and Federal governments act to help create a minimum stable base of housing and basic public amenities once and for all free of flooding destruction. Their need, present mitigative costs and an inequity across geography and income classes, can be solved by a non-structural strategy which combines genuine relocation opportunities in decent housing with comprehensive flood damage reduction.

2. Household Financial Disturbance Results

The purpose of this unit of investigation is to identify the extent to which the ability and willingness of households to participate productively in the economy is affected by flooding experience and to derive some logically expected human capital resource and dependency consequences of those effects which may recur to the national economy. This unit also furnishes some description of data distributions and relationships underlying the findings reported in the investigation units on psychological trauma and labor productivity in coal mining.

Flood experience variables including damages to home, whether forced to leave home, time out of home, depth of water in home, and loss of sentimental objects -- were related to psychological and physical variables on family's state of mind, charges in health, specific stresses, and family health score. These experiences were already shown to have had moderate to strong impacts on respondents' perceptions of their families' well-being.

Assuming the established psychological impact content of the flood experiences, those flood experience indicators were then related to household financial response variables -- including savings level, credit obligations, purchasing behavior, changes in forms of insurance, and requests for services and financial assistance from private and public organizations and programs. With the exception of purchasing behaviors (where results were negligible or equivocal) a number of adjustive financial responses imposed by the flood were moderately or strongly indicated. There is sufficient suggestion in these data to warrant future systematic investigation into the aggregate effect on the economy of the imposed changes on households glimpsed in this probe.

As a summary check on effects persisting two years beyond the flood, well after property damages, business losses, and emergency recovery costs had been tallied, survey respondents were asked if their families were "back to normal". The question was intended to encompass both the psychological self-assessments and the household economic indicators in a general estimate

or outlook. The negative responses indicating that households had not returned to "normal" are shown below as they are related to the major flood experiences:

Table 7: Effect of Four Experiences on "Things Back to Normal"

	Back To Normal	
	No	Yes
Damage to Home		
None	9.7	90.3
Little	0.0	100.0
Moderate	23.5	76.5
Severe	38.0	62.0
Ruined	52.4	47.6
		Gamma = -.52 at .000
Forced to Leave Home		
No	22.9	77.1
Yes	38.2	61.8
		Gamma = -.35 at .12
Time Out of Home		
1 Day or Less	11.1	88.9
2 Days to 1 Week	20.5	79.5
1 Week to 1 Month	36.1	63.9
1 Month to 6 Months	43.8	56.3
Over 6 Months	11.1	88.9
Permanently	55.3	44.7
		Gamma = -.42 at .0003
Loss of Sentimental Objects		
No	12.1	87.9
Yes	42.3	57.7
		Gamma = -.68 at .000

In summary, there is implication in the data of this study unit (supported by the psychological trauma damages estimate) to suggest quite strongly that human resources impairment persists long after public program monies have been spent for emergency services and "recovery". The effective capacity of people for normal participation in the economy may slowly decrease, following deterioration in the private property base and social infrastructure through which they must act to achieve productive ends. In short, with successive floods there is strong suggestion of a downward "ratchet" effect, a cumulative decline in the human resource capacity of individuals. There is reinforcing confirmation for this in much general data on the valley over the last twenty years of flood history.

A downward drift in wealth, psychological outlook, perception of opportunity, and economic choice follows recurring severe floods, even as government and privately supported flood recovery costs mount. This situation indicates a substantial federal advantage for investing funds either to control floods or to assist the resettlement of flood-threatend households to flood-free locations.

There is some specific point in judgmental concensus (if not in precise measurement allowed by study time and funds) where the recovery cost of floods becomes a welfare burden on behalf of an increasingly depleted human resource, and ceases to be an investment in genuine recovery. Investment in a permanent state of recovery is necessary to establish the productive capacity of a viable, confident, and capable socioeconomic system of people able to achieve and maintain living conditions which approach at least minimum national standards of well-being.

B. Non-Structural Plan Implementation

1. Relocation Opportunity Housing Analysis

The objectives of the housing analysis study unit are to provide information on the housing stock, housing preferences, and propensity of people to move.

It is assumed that a major component of adjustment to flood risks will be met by providing new housing in the valley which would enable residents in the floodplain who are at greatest risk to have the choice of moving to a new location where risk is reduced or eliminated.

The information provided should enable Corps planners to make some inferences about future non-structural approaches and provide basic data for some of the necessary planning decisions. Most critically, data on housing type preferences and the specific aspects of willingness to move will allow identification of those kinds of households likely to respond to new housing opportunities, thereby guiding plan implementation resources to those segments of the population where effectiveness will be maximum.

Current Housing Stock. The recent history of housing in the Tug Fork River Valley is one of frequent flood damage and destruction of a diminishing supply of housing that stands in contrast to the history of housing policy in the United States at large. There is a critical shortage of decent, safe, and sanitary housing that meets national standards and fundamental policy.

Forty-eight percent of the housing in the sample for this study (stratified by frequency zone) is in the zone where flooding has an expected recurrent interval of once in 20 years, or more frequently. Another 20 percent is in the 50-100 year zone and 28 percent is in the 500-year zone or above. This reflects the historical fact that individual initiative alone - against topographical problems of site development and pattern of corporate land ownership - rarely has any option but to build on the valley floor. As the data indicate, nearly three-fourths of residences are within the 100-year floodplain.

Four attributes of housing quality (beyond condition of structure and materials) were tested for relationship with flood frequency zones. Tenure (owner-renter), number of rooms and presence of bathroom were all found to vary by zone, although they are not linearly related to zone. The fourth characteristic - lot size - does seem to be nearly linearly related. Lots are smaller (therefore housing density higher) in the higher-frequency zones,

while more lots larger than one-half acre are located in the lower frequency zones. The design of both public information efforts and effective incentives for voluntary, self-selective relocation should take into account these and other zone-specific differences.

About 70 percent of floodplain residents are home-owners and 33 percent presently have mortgages. Many mortgages are rather short-term (10 to 12 years) because valley residents tend toward inability to maintain the value of their home at parity with their mortgage balances. Bankers also report that the average loan-to-value ratio is 20 to 30 percent.

There are a number of clearly identifiable factors responsible for the critical deficiency in both supply and quality of this housing inventory. Interviews with more than 50 officials in both the public and private sectors converged on the following obstacles and problems:

- Lack of suitable and available land for individual purchase;

- High site development costs due to (1) topography, (2) lack of infrastructure, (3) corporate land ownership;

- Absence of even a small building industry, and lack of skilled construction workers;

- Lack of long-term mortgage financing mechanisms;

- Lack of adequate transportation routes for movement of materials;

- Government regulations which the area cannot meet because of topography, economic, and labor constraints.

At present, the only alleviation of the housing situation described here is the modest expectation of less than 2,000 units. These are being provided by the efforts of HUD under Section 8, and by FMHA under Section 502, with the supplementary assistance of the West Virginia Housing Development Fund and the Kentuck Housing Corporation. Distributed across two states, few will be in the Tug Valley.

<u>Housing Preferences</u>. A number of indicators concerning satisfaction with present homes and neighborhoods were assessed. Present homes were considered ideal by 26 percent of the residents. Another 32 percent expressed a need or desire for a more elaborate home in some respect, while 14 percent replied that their ideal was simply a "decent" home. Eight percent stated that, ideally, they wanted a home safe from flooding.

Neighborhood attachment was examined in a number of facets to help interpret responses of stayers and movers. Aspects of neighborhood orientation asked about included:

What does it mean to you?
How satisfied are you?
How often do you talk with neighbors?
Would you miss it if you moved?
Would you want neighbors to move too?

The total content of responses indicated that neighborhood ties are quite strong. But about half of the 66 percent of the valley residents willing to move are indifferent as to whether any of their neighbors might move with them. Apparently it is neighboring relations - not particular neighbors - that matter to them, whether in their present locations or in new ones.

The specific house type preferences expressed included one dominantly expected result and one surprise contradiction of conventional wisdom (held by some local officials as well as outsiders) about the area. About half of the respondents' first choices were for a small, one-story, single-family, detached house. This simply affirms what is typical for the area and for non-metropolitan Americans at large. About one-fourth chose a rustic, A-frame, mountainside house which is not presently common in the area. About 15 percent rejected all five house types shown to them. The surprising result was that only 3 percent chose the mobile home. This may be a strong indication that they (and perhaps residents of other valleys) do not like living in "trailers" as is often asserted. This finding indicates that the present abundance of mobile homes is an outcome of unavoidable necessity, not free choice. Both garden apartments and high rise structures were also nearly completely rejected.

Propensity to Move. Respondents in the 278 households of the survey were asked this question: "If decent, affordabe housing were available to you outside the floodplain, would you be willing to move?" More than 66 percent answered "yes." Why this majority contradiction of the pervasive myth that people living in the floodplain are not willing to move out of it? It is mostly due to the absence of affordable housing in flood-free sites, so they haven't frequently moved. Behavior is heavily constrained by obstacles, but preferences are not. What most of the people want - are willing to do - is blocked off by three major obstacles. Small and dwindling supply of housing, especially outside the floodplain, has already been discussed and its six primary causes identified. A second obstacle to individual action is low family incomes, a pervasive constraint against many inclinations to self-betterment besides decent housing in the region. And third, there is a lack of long-term mortgage financing available, partly because of earlier-mentioned federal regulatons which often make qualification difficult in this area.

Conclusion. It is clear that the housing realities of the valley show many dimensions of both need and opportunity which might be successfully met by voluntary relocation and other non-structural measures. It is equally apparent that no single agency has the sole ability to bring housing and flood

control policy together. The Corps of Engineers has both the opportunity and the lead capacity for developing an innovative organizational arrangement with the Appalachian Regional Commission and housing agencies and organizations at all levels (public and private) to plan and administer a long-term housing development and relocation assistance plan which would greatly reduce long-term flooding risks and re-house an area long suffering from very poor housing.

2. Community Analysis

Objectives: The specific objectives of the community analysis for the valley were: (1) to assemble an inventory of populated places which are predominantly too small to be described in U.S. Census sources; (2) to develop a social profile consisting of several factors each of an economic, social, political and historical kind; (3) to identify the formative influences of present community organization and (4) to assess adaptability and capacity to respond to government assistance for flood damage reduction through a non-structural, voluntary relocation opportunity plan. The general objective of this study unit, like that of the housing analysis unit, is to provide planners with information which will help them to identify both feasible components and constraints toward development of a voluntary relocation plan.

Residential Place Inventory. By a research procedure of intersecting various maps, aerial photos, field inspection, and interviews, 103 named residential places were identified. They are distributed with a fairly even density in a strip development throughout the 130 miles from Ft. Gay to Welch, at an average interval of two and one-half miles, comprising a population of about 10,000 persons within the outer limit of the floodplain. Most are unincorporated and few have public facilities and services.

Social Profiles. In the social profiling process, some widespread image points about "Appalachia" were confirmed for this valley in particular: Labor participation is about two-thirds the national average, median family income is correspondingly depressed, and educational attainment level is low.

The Dun & Bradstreet credit limit, aggregated for rated firms in 22 towns in West Virginia and nine in Kentucky amounts to per capita availability of $36,238 in the former and $4,906 in the latter. In West Virginia six towns alone account for 99.4 percent of credit and in Kentucky two towns absorb 92 percent. Among listed "D & B" businesses in the Valley 20 percent are coal mines, 12 percent are manufacturing or construction, 15 percent are wholesalers, 40 percent are retailers and 10 percent are service providers. Most businesses are branch and not locally owned. In this context, local firm turnover (starts and failures) is rapid. Most businesses are also overwhelmingly sited in the floodplain.

Historically Formative Influences. One of the major influences which has shaped community and social organization as well as perspectives on life in the valley is the single-industry dominance of coal mining. It began to effectively shape the physical and social arrangement of the valley during World War I, when the

industrial production of Eastern cities generated a vast demand for coal. The dominance of the coal companies created a number of realities which remain as greater or lesser residues today.

First, in response to the national market demands large firms bought a large portion of mineral and surface rights on the land. The resulting ownership in large blocs limits its development for housing. Second, the coal industry offered high wages but erratic employment, because the industry has been characterized by frequent sharp cyclical downturns. Third, the coal companies - whether to provide infrastructure for maintaining a viable labor force or to control and exploit a vulnerable population - as one wishes to interpret history - often built company towns providing housing, goods and services. Benign or malignant, it induced dependence.

Cyclical employment, living conditions, work requirements and safety problems also generated a violent era of the labor movement - and yet another contact with large-scale organization in the form of unions. Railroads created another experience of dealing with large organizations controlled outside the valley.

More recently, the people of the valley have had other experiences of a <u>post</u>- industrial kind in common with more metropolitan Americans everywhere. The Kennedy/Johnson social welfare programs brought federal funds, new organizations, and a small share of wider American prosperity to a small but active segment of the local population. The lasting effect of those experiences has been rising expectations about many aspects of local life not presently at parity with minimum national standards.

The weight of these experiences since World War II, not so different from that of more affluent metropolitan Americans, is evidence squarely against a major dimension of the Appalachian stereotype. Despite the material conditions and economic depression of the area, it is not an isolated backwater of unsophisticated "hillbillies." The people can organize to assert their interests on specific issues, as they did in early unionization, and as they have with greater frequency and variety in the last 20 years. However, they have not, and cannot alone, overcome the intersecting problems of nature, history, and structural problems of industry, economics, and community which extend into and originate in American society at large.

<u>Capacity to Respond to Assistance and Change</u>. This study unit evaluated adaptability to change and capacity to respond to the complexities of planning and development in a constructive, participating manner. Two empirical generalizations result which reassure prospects for success of the extensive interaction necessary to plan and implement a voluntary non-structural program. One generalization is that people are attached to the Tug Fork Valley, not to their particular locale or community of residence. The other is that there are potential resources in individual characteristics and organizational experience adequate to implement a voluntary relocation strategy.

People are not attached to the immediate community or site of residence for a number of reasons. First, they commute long distances to work, in large

numbers; and they live at such remote locations because the scarcity of housing makes residential change hard to achieve. Hence they often don't live where they do because they wish to stay. Commuting also diffuses their familiarity across many communities. A second reason for diffuse attachment is that civic orientation and political decision-making have historically been focused at the County level, rather than the community level. A third reason is that business, professional, fraternal and religious organizations do not coincide with municipal or community boundaries.

The resources for local leadership assistance and organizational competence are also suggested by several clear indicators. One indication of response capability is the residents who are identified as "cosmopolitans" in this study. They are professionals and managers who either belong to long-established families of the area or have migrated in as branch employees of non-local firms. Many corporate policies encourage employee civic responsibility. This may be especially likely in the Tug Fork area if an opportunity to improve community facilities and services is perceived. "Cosmopolitans," in short, are a pool of potential local talent.

Another indication which suggests response capability is the experience of people who have interacted with Federal, regional, and State governments to implement welfare and development programs during the last 20 years. Above the municipal or community level, the area actually has a fairly dense system of formal organization and professional expertise. A fully designed strategy of coordination would probably be a sound administrative investment.

Conclusions. This assessment has evaluated the characteristics of residents, organizations and institutional bases and communities. Historically shaping experiences show the potential for positive response and adaptation to change. They suggest several opportunities and constraints for planners. First, contrary to physical community appearances, most of the population have extensively experienced the process of urbanization. They are very much linked into national American culture through coal, unions, Federal programs, large educational sector, migrant professionals, and TV. This fact means that a voluntary relocation program should be perceived as collaboration in common goals, not as outside intervention.

Second, most of the floodplain residents would move to an affordable flood-free location. This is a double-edged truth. Providing safe and affordable housing along with a reasonable system of supporting community services is a formidable objective.

Finally, there is a constraint stemming from the understandable focus on the potential of coal mining to solve most problems toward achieving the good life. When the aftermath of a flood has been cleared away and the losses accepted, not many people have developed an insight into the role that cumulative flooding costs actually play in blocking wealth accumulation and trends toward a more diversified economy.

The wider, more complex linkages among single-industry oscillation, flood losses and threat, depressed income, and lack of public infrastructure for "take-off" must be locally understood if help is to be received in a partnership working toward change.

III. Implication of Findings

This study has produced estimates of flood damages due to the psychological trauma experienced by persons exposed to the flood, and damages due to reduced coal mining productivity. The estimated $95 million loss due to psychological trauma shows the serious human consequences of the 1977 flood. To put this in perspective, residential property losses were estimated at slightly over $40 million. Forty-seven hundred homes were damaged, 600 of them totally destroyed. Property losses of $9,000 occurred to houses which averaged only $11,000 in value. Therefore, the cost due to psychological trauma exceeded residential losses. Physical losses to all categories of property totalled totalled $126.6 million. We believe that this analysis establishes a logical argument that non-property flood damages are a significant component of total damages and that they should be evaluated.

Our analysis of the impact of flooding on coal mining productivity shows that elimination of the flooding would result in a net increase of about $25 million in coal output from the valley. The Tug Fork Project damage survey showed 500 workers were out of work for periods from two weeks to eight months due to the flood. Two mines have not reopened. Our estimates of adverse productivity impacts are cast in the context of long run differentials in productivity, since we used data from years in which there was no major flood or strike.

Thus flooding has substantial adverse economic impacts in excess of property losses and emergency costs. In the Tug Fork case, there is another category of impacts for which no estimates have yet been made. That is the cumulative impact of five major floods in 20 years on the local public sector's ability to deliver public services. There is a negative reinforcing cycle working back from the very low property values in the flood plain which tend to limit revenues to local government, and on the other hand the special additional cost which the community which must bear because of their flood prone location and the occurrence of frequent major floods. One example, for instance, is that the health services office put in operation at Materwan just a year before the 1977 flood. The facility required a heroic effort by the City Council and Mayor to obtain funds, build a building and recruit health service proposals to the community which had no other comparable health facilities. Yet the building was lost in the flood and two years later no replacement had been implemented. This is a small example of a large problem. One of the results is that the Tug Valley has a very low level of locally provided public services--a deficiency which results in no solid waste management program and pervasive dumping of waste material along the roadside and stream banks.

The second major element of the study was to evaluate the feasibility and impacts of voluntary relocation and rehousing programs. Here we found that a substantial majority of the residents were willing to participate in voluntary relocation. The problem may be, under what conditions? Since the Huntington District is identifying flood free alternative sites a[illegible] costing out development costs, there is evidence that this type of strategy is physically feasible. Public action to acquire the sites (which are in large

part owned by outside firms) is likely to be necessary. However, there are several examples where large mining companies, businesses and other groups have found a way to provide housing sites. Then the problem is to find site developers and housing firms. This will require either outside firms or development of the capability in the valley. Given housing, the next problem is financing. Again, significant structural changes must be made to move to the position of available, long-term low down payment and reasonably low interest loans. Next, people living in $11,000 houses are not likely to be able to afford even modest new houses in new sites which are likely to cost in excess of $50,000 for the house and the site. However, there are many housing assistance programs available from HUD which, along with relocation assistance payments may close the gap in financial feasibility. Finally, if the new homes are built to subdivision standards and a full set of public services required, local taxes are going to have to increase substantially. Some HUD programs may mitigate this problem but clearly it could become a major stumbling block. If the rehousing program is a success, not only will there be a sharp reduction in flood losses, but the Tug Fork Valley community will begin to achieve some parity in housing quality with other comparable communities of the United States. Housing benefits may ultimately exceed flood damage reduction benefits.

Since the Tug Valley housing is located in a linear strip along the river, many types of communities are evident. After Williamson, the largest community of about 4,000 population, and Matewan, about 1,200 population, community size quickly declines to a great number of very small communities with place names. There is limited tradition of active local decision making at the town level -- because of a history of county level decisions, the prepondence of outside large-scale organization influences, i.e., the coal companies, the unions and federal programs. People commute long distances to work. Political organizations seem to focus on Valley rather than town issues. All of these factors suggest that people can relocate without a strong sense of community loss.

These studies suggest some guidelines for implementing mixed structural and non-structural plans. First, a project of this magnitude will involve the best that Federal, State and local government have to offer. It will test some of the program criteria (which tend to be written without areas like Tug Fork in mind). Tug Fork has a limited record of accomplishing complex public objectives by its own leadership. That leadership must be stimulated and developed. Rehousing 2,000 families is a job which directly affects about 20 percent of the Valley population. New communities and a new community support mechanism will have to be developed. The Federal and State governments must work as partners with local communities. If the rehousing can be accomplished, substantial improvements in the quality and quality of life in Tug Valley would be likely. The Valley would be more productive and competitive. Environmental quality and life quality will improve. Communities will be able to more nearly master their own destiny. The Nation will gain more coal and reduce a dead weight drain for resources to supply social support services to people who cannot compete. Central Appalachia can assume a positive role in national development.

V. Conclusions

The human costs of flooding are large and have been quantified. In the Tug Valley they are almost double losses to residential property. Flooding can also increase the long term requirements for social service support by the Federal and State governments. These expenditures are necessary and unavoidable given the needs, but seldom act to change peoples ability to compete.

Voluntary relocation is one of the potential solutions to the Tug Fork flooding problem. Benefits are due to reduction of flood damages and to improvements and housing. An important byproduct will be communities which can finance and deliver a more comprehensive set of public services and thereby maintain cleaner, safer communities. We have found that voluntary relocation can be implemented. A large majority of the people are willing to move away from the flooding hazard. They can form new communities without a great sense of loss of the old community. Tug Fork residents have moved--from the hollows to the highways--and from Tug Fork to industrial cities and return. Therefore, voluntary relocation cannot have serious adverse impacts.

Rehousing 20 percent of the Tug Fork community is a large task. The Valley is not now equiped with the kind of development, financing, and house building industry to accomplish the task. Development of this capability, largely from Valley resources (people and managerial capacity) should be an important element of the implementation strategy. Many program regulations will have to be altered to rationalize this rehousing strategy. Rules written without Tug Fork realities in mind will have to be revised. But regulatory flexibility in this case of humane and national interests would be both prudent and efficient.

AD P002640

A Review of Discount Rate Models for Evaluating
Water Resources Projects

by James Tang

and Lloyd G. Antle

April 1982

U. S. Army Engineer Institute
for Water Resources
Fort Belvoir, Virginia

Revised Draft

A Review of Discount Rate Models for Evaluating Water Resource Projects

A review of Discount Rate Models for Evaluating

Water Resource Projects

I. Introducton

Under current procedure, the future benefit stream of a water project must be converted into its present value for comparison with its present and anticipated costs in a benefit/cost ratio. This ratio must exceed unity for most projects to be recommended for Congressional authorization. Obviously, a high discount rate would tend to discourage water projects more severely than other projects since most water projects are high in initial costs and long in payback periods. For over a decade, the discount rates used for water resource planning have been based on the long-term Treasury bond yields and are determined every July by the Water Resources Council in consultation with the Treasury. The official rate was 4 5/8 percent when the current procedure was put into effect in 1969. Except for 1973, the official rate has increased since 1969 by one fourth of one percent every year and now stands at 7 5/8 percent for fiscal 1981.

The determination of an appropriate discount rate for public investment projects has been and will continue to be a subject of intense debate. A joint Congressional committee hearing was held on the subject in 1968, from which many important ideas and formulas on discount rates were presented,

which are still popular today. However, there is no agreement in past and current discussions as to what is the best way to determine a discount rate that would satisfy the economic efficiency criterion. While academic discussions of the subject continue, pressure is mounting for reform of the rate which is deemed too low compared with the current rate of inflation. Then-President Carter proposed such a reform in 1977, but failed to carry through, having reversed his position. While the new administration has not yet taken any formal stand on the discount rate policy, the discount rate is expected to be subject to high-level policy review.

The lack of agreement on an acceptable procedure and a single discount rate over more than a decade is largely due to the complexity of our economic system. Unlike the situation in a simplified competitive economy, there is more than one interest rate in a mixed economy because the capital market is imperfect and there is divergence between public and private values. The rates of return, including interest rates, can be quite different from one business to another - reflecting the differences in risks and uncertainty, taxes, and institutional constraints. Since a representative rate of interest cannot be directly observed in the market, various models were constructed to explain the differences and to infer what may be considered a reasonable estimate of the appropriate interest rate.

The discount rate models selected for review here may be identified under three categories: the social rate of time preference model, the cost of borrowing model and the opportunity cost model. Before the review some definitions of the terms used in this paper are presented.

1. "Discount rate" refers to the rate for use in converting future values (benefits or costs) into their present worth. In a purely competitive economy, the discount rate is assumed to be identical with the market interest rate or the rate of return.

2. "Interest rate" refers to the cost of borrowing money, expressed in percentages of the principal. Under the assumption that an investor must earn as much as the cost of borrowing money measured by the interest rate, the market interest rate is advocated by many writers as the appropriate discount rate for the analysis of public projects and hence, interest rate is used synonymously with "discount rate" in the context of public investment analysis. In other words, when the term, interest rate, is used interchangeably with the discount rate it is implied that the interest rate chosen (usually market rate adjusted for risks and inflation) is - or should be - the discount rate. To avoid confusion, this paper uses the term, interest rate, in its common-sense definition: the cost of borrowing money.

3. "Rate of Return" refers to the money return on invested capital (fixed assets). As used in the literature, it represents the profit margins on an annual basis, before or after taxes.

II. Determinants of Interest Rate

Since interest rate is a crucial consideration in the determination of an appropriate discount rate for public investment analysis, it may be helpful to

say a few words about how interest rates are determined, as explained in economics literature.

The classical economic theory holds that interest is the price of borrowing money or the reward for saving. The interest rate equates the supply of funds saved by households to the demand for funds by businesses and households. In other words, the equilibrium rate of interest is determined in the competitive economy where the supply of saving by households equals the demand for investment by businesses.

A new theory of interest emerged after the Great Depression of the thirties. The new theory is an important part of the Keynesian general theory of income and employment which has had considerable influence on contemporary fiscal and monetary policies of the United States. The theory holds that the rate of interest is determined by the demand for and supply of money. On the demand side, the demand for money is determined by the marginal efficiency of investment (or profitability) which must exceed the rate of interest for investment to take place. On the supply side, the supply of money is determined by the liquidity preference and the quantity of money. The liquidity preference is found relatively stable over time. The quantity of money, on the other hand, is determined by the monetary authority and the central bank through its control over open market operations, reserve requirements and other factors.

The important thing to remember from the new theory is that under a less-than-full employment condition, the Government can increase the money supply, thus lower the interest rate and stimulate the investment demand, rather than

leaving the market to seek its own equilibrium. In recent years, the Government has played an increasingly decisive role in both the financial and capital markets and thus exerted much more influence on the market interest rate than ever. We will complete this introductory section by providing a glimpse of the trends in various measures of return to capital, cost of capital and discount rate.

Chart 1 is a geographic presentation of such measures, including the official WRC discount rates for water projects. Several observations may be made: (1) Between 1970 and 1978, there was a stable relationship between the official WRC discount rates and the private and Treasury long-term, and Treasury constant maturity bond yields as a group. (2) Between 1970 and 1978, the official WRC discount rates were not found to be lower than 2 percent points of the Treasury bonds at constant maturity. (3) The rates of return to manufacturing corporations showed an average of 6-7 percent during the period 1970-78, with a sharp decline in 1973 and 1974. (4) The official WRC discount rate of 6 3/4 for fiscal 1978 coincided with the average rate of return for manufacturing. (5) The bond yields and interest rates rose sharply since 1978 and are continuing to rise, reflecting the effects of inflation.

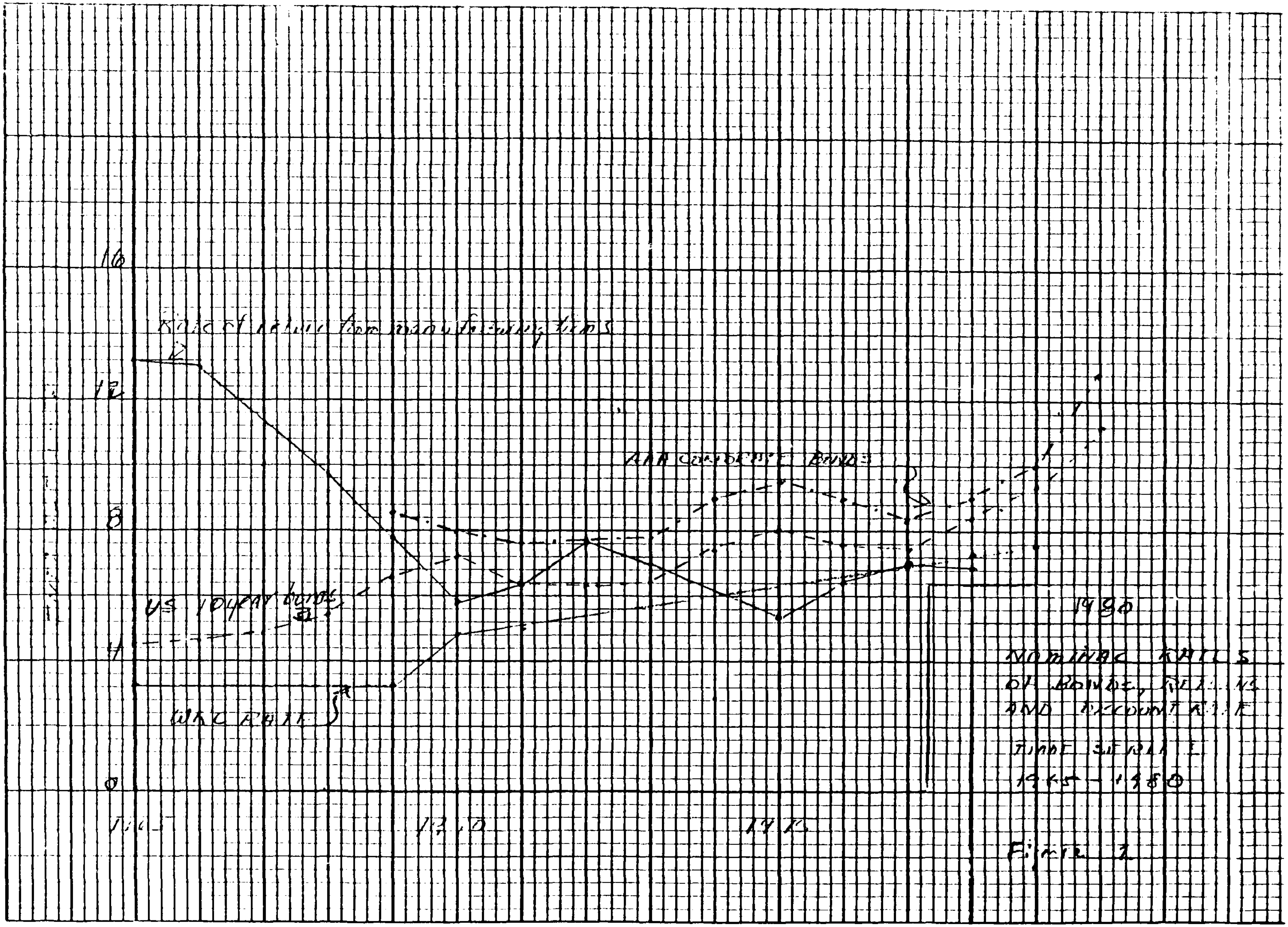

16
12
8
4
0
Rate of return from manufacturing firms
AAA corporate bonds
US 10 year bonds
1970
1975
1980
NOMINAL RATES
OF BONDS, RETURNS
AND DISCOUNT RATE
TIME SERIES
1965 - 1980

Figure 1

III. Impacts of Interest Rate on Benefits, Costs and the Benefit/Cost Ratio

The interest rate directly determines the amount which must be deposited each year to repay a project. The interest and ammortization factor converts a capital investment cost into annual costs. Interest rates also determine future values. Benefits in future years are discounted to present values at the appropriate interest rate and converted to average annual equivalent values to be compared with annual costs in the B/C ratio.

The impact of increases in interest rates is to increase annual costs approximately in a linear relationship with the change in interest rates and to reduce the annual value of future benefits by considerably more than a linear relationship. Thus the benefit/cost ratio is impacted in both parameters in an increasing function.

These impacts are magnified by the length of time in which benefits are increasing, by the ratio of first costs to annual operation costs, and by the design life for an investment project. Projects which have a high initial capital cost show a highly sensitive reduction in the benefit/cost ratio as interest rates increase. Future benefits are sharply reduced by increased interest rates. Long design life is at an increasing disadvantage as interest rates increase.

The fundamental influence on future benefits is shown in Figure 2. The present worth of a dollar's worth of benefits at some future time is $(1+I)^t$, where I is the interest rate and t is time. The fraction declines by a compound rate and asymptotically approaches zero. At year-10, a dollar is

worth about 74 cents at 3 percent, 52 cents at 7 percent, 38 cents at 10 percent and less than 30 cents at 13 percent rates.

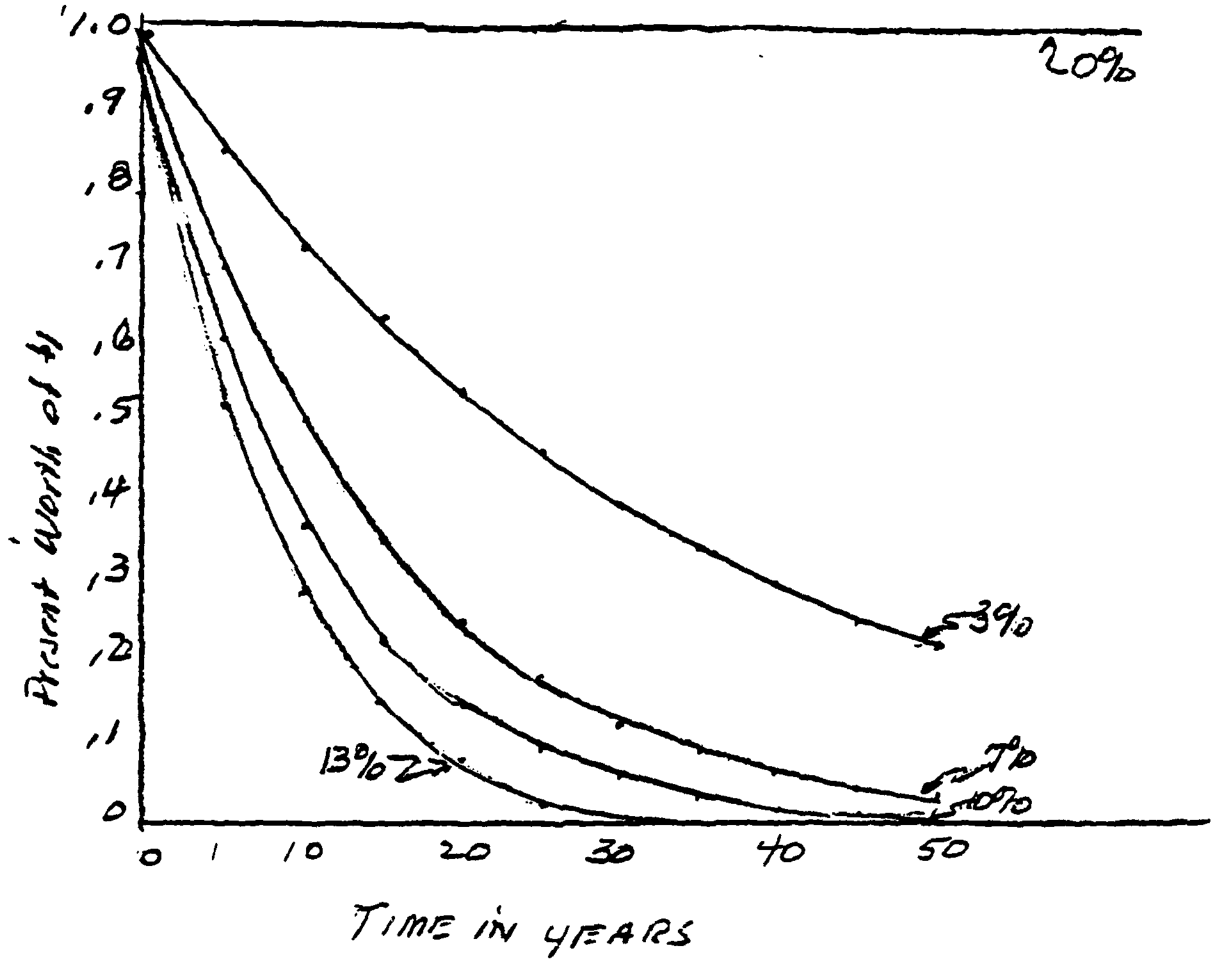


FIGURE 2 Present Worth Factors

The following tabulation shows the impact of various interest rates on the average annual costs of a project costing a million dollars for construction and $20,000 annual operation and maintenance (O&M). The changes in annual costs are approximately linear with respect to the interest rate.

Interest Rate	Int. and Amort.	O&M	Total	Change in Interest	Change in Annual Costs
0	10,000	20,000	30,000		
				3	31,650
3	31,650	20,000	51,650		
				4	38,430
7	70,080	20,000	90,080		
				3	29,927
10	100,007	20,000	120,007		
				3	29,993
13	130,000	20,000	150,000		

The following tabulation shows the impact of various interest rates on the average benefits of a 100-year project in which benefits increase on a straight line from 0 at the beginning year to $1,800,000 per year at year 100.

Interest Rate	Discount Factor	Average Annual Benefits	Change in Benefits
0	0.5	900,000	
3	0.2024	364,320	535,680
7	0.1517	273,060	91,260
10	0.10997	197,946	75,114
13	.08607	156,456	41,490

There is a non-linear relationship between change in the interest rate and change in the average annual benefits accruing from future increases in benefits.

The following tabulation shows the impact of various interest rates on the average annual benefit/cost ratio of the project shown in the preceding paragraphs.

Interest Rate	Annual Benefit	Annual Costs	Benefit/Cost Ratio
0	900,000	30,000	30
3	364,320	51,650	7
7	273,060	90,080	3
10	197,946	120,007	1.6
13	156,456	150,001	1.005

Interest rate has other important impacts on project design and choice between alternatives. Increase in the interest rate will drive the design of projects towards short life and high O&M. This can easily be shown in the following tabulation. It shows one projecr costing one million dollars for construction and \$20,000 annual O&M over a 100-year economic life compared to a \$250,000 first- cost project designed for a 30-year economic life with \$100,000 annual O&M costs. We assume a straight line growth in benefits reaching \$1,800,000 a year for the first project and \$540,000 a year at year-30 for the second project.

	100 year project	30 year project
Life Cycle Costs (not discounted)	$3,000,000	$3,250,000
Life Cycle Benefits (not discounted)	$90,000,000	$8,100,000

Average Annual Values ($000)

	100 year project life			30 year project life		
Interest Rate	**Costs**	**Benefits**	**B/C Ratio**	**Costs**	**Benefits**	**B/C Ratio**
0	30	900	30.0	108	270	2.5
3	52	364	7.0	113	241	2.1
7	90	273	3.0	120	193	1.6
9	120	198	1.7	127	165	1.3
13	150	156	1.04	133	142	1.07

While the numbers are contrived to show a point, the message is important. High interest rates make short-term projects appear to be preferable and favor the designs which require more O&M relative to first costs.

Finally, high interest rates reduce the economic merit of hydropower versus less capital intensive thermal projects which use expensive fuels.

The following tabulation shows a series of 50-year project alternatives which provide the same benefits and therefore would be selected on the least annual costs basis.

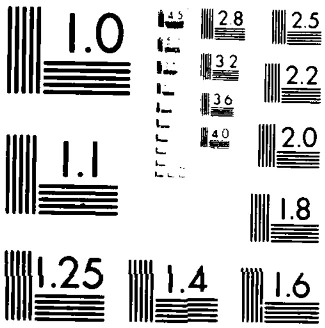
Project	1	2	3	4
First Cost ($000)	**1,000**	**500**	**250**	**100**
Annual O&M ($000)	**50**	**100**	**150**	**200**
Life Cycle Cost ($000) (Undiscounted)	**3,250**	**5,500**	**7,750**	**10,100**

Annual Charges ($000)

Interest Rate	1	2	3	4
0%	$\boxed{65}$	110	155	202
3	$\boxed{89}$	119	159	204
7	$\boxed{122}$	136	168	207
10	$\boxed{150}$	$\boxed{150}$	210	210
13	180	$\boxed{165}$	182	213
20	250	$\boxed{200}$	200	220
30	350	250	$\boxed{225}$	230
35	400	275	238	$\boxed{235}$

AD-A136 867 PROCEEDINGS: ECONOMIC AND SOCIAL ANALYSIS WORKSHOP HELD AT ST LOUIS MISSO..(U) ARMY ENGINEER INST FOR WATER RESOURCES FORT BELVOIR VA L G ANTLE OCT 83 IWR-83-P-40 3/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

While the comparison has been run into extraordinarily high interest rates, there is a moral. High capital/low O&M projects stand to lose their advantage in discounted annual charges as the interest rate is raised. The most expensive life cycle cost project (project 4) which costs over three times as much as project 1, becomes the optimal selection at a 35 percent interest rate. The encircled figures show the optimal selection between the alternatives at various interest rates.

To summarize, using higher interest rates not only increases annual costs, but also reduces future benefits by an even larger amount and thus adversely affects the benefit/cost ratio. High interest rates bias decisions away from the high capital/low O&M projects in favor of a higher ratio of O&M to capital. Projects of long-run benefits lose their appeal and short-lived projects are encouraged. Finally, selection of alternatives (particularly hydropower) is biased against high capital-low O&M technologies. Why does the interest rate attract so much policy attention?

The appropriate interest rate, to be used in evaluating and formulating Government investment programs has been and will continue to be subject to much debate. The economics profession continues to play an important role in keeping the issue and the debate from abating. However, the impact of the interest rate used in planning Government investment programs is so direct and pervasive that economic advice is rarely the sole criteria for policy decisions. It is at heart a fundamentally philosophical basis on which most political and policy factors make their claims and ultimately their decisions.

The economist's argument is simple and direct. Capital resources can be used for public projects only by denying other potential investors or consumers the use of their resources. Unless the resources (concrete, steel, labor, etc.) are and would continue to be unemployed in the absence of the Government project, there is a positive price. Capital resources would normally generate returns to investors and alternative users and, therefore, Government projects should be undertaken only when they yield competitive returns. The interest rate is the market's indication of value which capital resources generate in competitive uses.

It is easier to articulate the general argument for the correct rate of interest than to determine the exact number. The capital market is not a perfectly competitive market, and, therefore, one has to cope with a large number of observable interest rates. They reflect institutional factors and other factors which must be adjusted to compute the pure interest rate:

$$R_m = R_1 + \text{risk} + \text{inflation} + \text{institutional} + \text{taxes}$$

where R_m = market rates of interest

and R_1 = pure interest rate

That is, one has to account for risk, inflation and institutional and tax factors to come to a position from which a recommendation, and ultimately a decision about the appropriate interest rate would follow.

In a later section of this paper a number of empirical estimates based on various models which represent economists' recommendations for tackling the direct interest rate are presented.

IV. The Social Rate of Interest Models

a. Political Decisionmaking

Marglin (1968) argued for the social rate of interest based on choice by political decisionmakers. He argues that political decisionmakers are the only legitimate institutional representatives who can fully reflect the interests of future generations. Therefore, they should select projects (and indirectly signal the implicit interest rate) based on information given by the planning agency about rates of return from the alternatives which meet the objectives of the public programs. Other writers have argued that it is not the interest rate but the level of investment made which would control the distribution of benefits and costs between generations. Marglin argued for a low interest rate (about 3 percent real rate).

b. Pure Social Rate

Arrow and Kurz (1970) represent a group of theorists who have developed a theoretically optimal social rate of interest in the context of a growing economy. They view the problem of selecting a proper discount rate as one of making simultaneous optimal investment choices now and in the future. A dynamic programming approach is suggested to solve for the optimal investment over time taking into consideration the natural rate of growth of the economy

and the fiscal instruments available to the public authority such as debt and tax policies. The proper interest rate under this theory approximates the rate of growth of the economy, or the natural rate of interest.

Following this logic, the planning interest rate should be derived from short-run interest rates.

V. Cost of Borrowing Models

The current discount rate is based on the average long-term Treasury bond yields as determined every July by the Treasury Department. The rate represents the costs of borrowing to the Treasury. Prior to 1969, such costs were determined on the basis of the coupon-rate rather than actual yields. The coupon rates remained at the low level of 3 1/4 percent for many years although investors could raise the yield by buying the securities at less than face value. Under intense pressure and after a rather extensive Congressional hearing, a new rate of 4 5/8 percent based on yields was established to become effective for FY 69 with provisions to rise by not more than one-fourth of 1 percent annually. The rate has gone up every year since except for FY 73 and stands at 7 5/8 for FY 81.

Critics of the current practice cost advocates argued for rates between 7 and 10 percent instead of the initial rate of 4 5/8 percent proposed for FY 69. However, such arguments were rejected for three reasons: (1) The real rate of return from marginal private investment and real yields to savers were in the neighborhood of the WRC rate; (2) If the initial change were too large, it would entail disrupting adjustments to planning programs, particularly on cost

sharing arrangements. It would be impractical and undesirable. (If the proposed new formula were based on the average June prices of Treasury bonds, then the FY 69 rate would be 5 1/4 percent, a difference of 2 1/4 percent from the 3 1/4 percent then in existence. Thus the new rate was set at 4 5/8 percent, limiting the change to 1 3/8 percent); and (3) The degree of yearly fluctuation in the discount rate needs to be dampened, not accentuated.

Critics of the current procedure were concerned not only with the level of the discount rates but took issue with the conceptual basis of the present procedure. They contended that the current formula is indefensible except for its simplicity. They argued that borrowing costs to the Treasury are merely financial costs, or budgetary concepts and the real costs are the inputs or resources that would have remained in the private sector for consumpton and investment in the absence of Government borrowing and investing. In short, it is the opportunity cost of capital and not the financial cost of borrowing that should be considered in discount rate determination. More on this later.

The current procedure seems to perform rather well over the years. It seemed to work satisfactorily at least until the current upsurge in interest rates and continuous inflation in the economy. This personal impression may be supported by the following observations: (1) The initial rate of 4 5/8 percent may have been low to its critics, but represented, nevertheless, a 42 percent increase or 2 1/4 percent higher than the previous coupon rate of 3 1/4 percent, (2) the discount rates have somehow caught up with other indicators of the costs of capital due to the annual adjustment mechanism.

(3) from the development agency's viewpoint few projects were turned down on account of B/C ratios at the authorization process; it was during the appropriations process that actual investment in water resources projects experienced declines, (4) the Administration may be reluctant to adopt a higher rate, as in the case of President Carter, in order to retain certain flexibility or for political reasons. In other words, there is a strong tendency to maintain the status quo.

The GAO Model. A variant to the cost of borrowing approach to discount is the theory that the taxes foregone should be added to the costs of borrowing at the capital market to reflect the costs to the Treasury. It is based on the assumption that the Government would lose tax revenues it would have collected from businesses and individuals if they were not denied the opportunity to invest by virtue of the Government investment. The proposal was presented by GAO at the 1968 hearings.

The GAO discount rate formula as illustrated in its report to the Joint Economic Committee in January 1968 was determined by basing it on the current interest cost of borrowing long-term money (4.0 percent in this illustration), plus foregone taxes totalling 4.9 percent, and minus income taxes collected on Government interest payments at 1.4 percent, resulting in 7.5 percent as the borrowing cost to the Treasury. The complete procedure is fully explained in Appendix III of the original report and is reproduced and appended to this paper for ready reference.

In an alternative method, GAO came up with 7.6 percent as the cost of borrowing. This method was on an aggregate basis, assuming a composite corporate and personal tax rate of 50 percent and a taxable return of

10 percent on any money not borrowed by the Government, and subtracted from above the taxes on Government bond interests.

What would the discount rate be if the GAO method were applied for the year 1978 (a year before the surge in interest rates)? Taking one-half of the difference between the official WRC rate and Government long-term bond yields, and add this to the WRC rate as the cost of Government borrowing, equals approximately 7.5 percent (obtained from Chart 1), plus the estimated taxes foregone of 5.0 percent (same number used by GAO), and minus 1.4 percent for taxes on Government bond interest. This would yield an estimated 11.1 percent as the cost of borrowing to the Government for FY 78.

While the GAO-proposed formula reflects a position advocated by some opportunity cost advocates, some economists argued that the GAO formula has left out many other taxes such as state and local sales and other indirect taxes. The main criticism, however, was that the narrow focus on costs to Government in the GAO approach should be broadened to reflect the costs to the economy. To compute the costs to the economy in the manner of the GAO illustration, the overall opportunity cost of incremental Governmental borrowing to the economy represents the sum of the opportunity cost that is lost due to Government borrrowing in each relevant sector. The computation is shown as follows:

Source of Funds	Percent of Incremental Borrowing	Relevant Opportunity Cost %	(1)X(2) %
Displaced corporate investment	50	15.0	7.50
Displaced non-corporate investment	25	8.5	2.23
Displ. owner-occupied housing const.	15	4.8	0.72
Newly stimulated savings	10	3.3	0.33
Overall Opportunity Cost			10.68
			rounded 10.7%

Source: Testimony of Arnold C. Harberger, in Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis, Hearings before Joint Economic Committee, 90th Congress, 2nd Session, 1968. p. 62.

In all the proposed formulas, the results of computation can vary significantly not only because the basic data (such as the initial bond yields chosen) are different, but also because the definitions, the weights, and the assumptions can vary widely from one model to another and even from one author to another using the same model. Substantial research is necessary if the various models were to be comprehensively updated by using currently available data.

VI. Oportunity Cost Models

The following section outlines three major positions (and interest rate estimates) advanced in the literature. The first application by Seagraves (1969) is based on corporate bond yields adjusted for risk and taxes. The second approach by Stockfisch (1968) is based on pre-tax rates of return from assets in the private sector. The third approach by Haveman (1968) is based on weighted private sector interest rates on household savings and business investment.

Adjusted Corporate Bond Yields (Seagraves & Hanke)

Corporate bond yields approach by J.A. Seagraves (1969) started out with an average yield on Class A corporate bonds and adjusted for risks, corporate profit and property taxes and obtained so-called marginal productivity of capital. The MPC was further adjusted for added savings to derive the social rate of discount in money terms. A social rate of discount was obtained after adjustment for inflation. The result as shown in the following table yields 8-13 percent as the discount rates.

Opportunity Cost Model OC_1, Seagraves, 1969

Basic Factors Affecting the Discount Rate	Social Rate of Discount		
	Lower Limit	Upper Limit	Alternative Computation (Dec.'69)
		Lower Limit	
	%	%	%
Yield on Class A corporate bonds	6.7	7.2	8.7
Risk premia for Gov't. portfolios	+2.0	+4.0	+3.0
Corporate profit and property taxes	+4.3	+6.0	+4.3
Marginal Productivity of Capital	13.0	17.2	16.0
Adjusted for Added Savings	-1.5	-1.5	-1.5
Social Rate of Discount in Money Terms	11.5	15.7	14.5
Adjusted for Expected Inflation	-3.5	-1.5	-3.0
Real Social Rate of Discount	8.0	13.2	11.5

Source: J. A. Seagraves: More on Social Rate of Discount in Quarterly Journal of Economics, pp. 430-450, Vol. LXXXIV, 1970.

The author offered the following comments on his computation: (1) The Class A corporate bond was chosen because such bond is subject to state and local taxes and its price has been more stable than the equity stocks. (2) He favors a moderate risk factor for Government investments just to be "fair" to enterprises that are not as diversified as the Government portfolios. The risk factor was inferred from a study's finding that the average standard deviation for returns to equity in large industrial firms is about 3 percent. (3) The effects of taxes were based on studies by Baumol and Stock ... ch under various assumptions. (4) The author was in favor of removing the ...luence of inflation on the discount rate; the inflation factors represented ... own view at the beginning of the Nixon administration.

Seagraves did not explain the nature of the negative adjustment for added saving. This adjustment, known as the Harberger effect, also employed by Hanke in his model which will be discussed later in this paper, was explained by Hanke as follows: An increase in Government spending, with taxes held constant, will result in a small increase in the rate of interest. This will result in a reduction of private investment and an increase in current savings. Consumption and investment are not permanently lost, however, they are only delayed. The value of National income foregone by these delays is estimated by taking the appropriate rates of interest times the reduced amount of current investment and consumption. This loss (deferral) will cause a net reduction from the nominal yield on private capital production of approximately 1.5 percent (Seagraves, 1961).

Using the same model but substituting the values on the yield of AAA corporate bonds and on expected inflation, Hanke came up with the real rate of discount ranging from 8.5 to 10.5 percent as of December 1978. His computation follows:

The Opportunity Cost of Capital, December 1978

Yield on Corporate AAA bonds	9.3 %	
Private Sector Risk Premia	3.0	
Corporate profit and property taxes	4.3	
Opportunity Cost in Production	16.6	
Adjustment for added savings	-1.5	
Nominal Public Rate of Discount	15.1	15.1
Expected Long-run Rate of Inflation	-4.6*	-6.6*
Real Public Rate of Discount	10.5 %	8.5 %

* Estimates made by the author as of December 1978; all other estimates taken from Seagraves' 1970 article.

Sources: Steve H. Hanke and James Bradford Anwyll: On the Discount Rate Controversy, in Public Policy, Vol XXVIII, Spring 1980, p. 181.

The model is relatively easy to understand although most of the other parameters are difficult to determine without making arbitrary assumptions with respect to tax structure, losses from added savings, and inflation expectations. This explains why Hanke has to rely on some of the values that were determined by different authors a decade ago when he estimated a new discount rate for 1978. Assuming two different figures from official publication (The Statistical Yearbook of the United States, 1980), 8.7 for yield on corporate AAA bonds rather than the 9.3 used in Hanke's 1978 estimate and also employ the (GNP) price deflator of 6.8 percent for 1978 instead of the inflation factor of 4.6 percent in his calculation, we would end up in a lower real rate of discount in real terms, or 7.7 percent compared with Hanke's 10.5 percent as the upper limit.

Rate of Return on Earning Assets (Stockfisch)

The Opportunity Cost Model OC_2, as argued strongly by J. A. Stockfisch, the rate of return on earning assets (asset-based earning) should be the basis for the social rate of discount. The following steps were used in the calculation of the social rate of discount, which is a weighted average of the rate of return on investment in assets in the private sector:

1. 15 percent rate of return for manufacturing and 10 percent for regulated utilities.

2. Allocate the business investment in plant and equipment 70 percent to unregulated sector and 30 percent to regulated sector and use these rates to determine the weighted rate of return to business investment to be 13.5 percent.

3. Add 1.5 percent to the weighted rate of return for property taxes. The resultant 15 percent represents the overall rate of return in the corporate sector.

4. As determined by separate studies, the importance of corporate and non-corporate sectors is 60 percent of the non-corporate sector and 40 percent of the corporate sector. It is also found that the rate of return in the non-corporate sector is about 10 percent.

5. Weight the 15 percent corporate return and the 10 percent non-corporate return at 40 and 60 percent, and we obtain an overall estimate of 12 percent as the rate of return before corporate and property taxes for investment in the entire private sector.

6. Subtract the inflation rate of of 1.6 percent from above to obtain the real opportunity cost of return of 10.4 percent.

This opportunity cost model agrees with the basic theoretical concept that private sector activity is displaced and its returns foregone when public investment diverts real inputs from the private to the public sector. Criticism of this approach is fundamentally concerned with the fact that the model requires many basic judgment factors used to identify the location of to define and to weight the private sector's rate of return.

Market Rates for Household Savings and Business Investment (Haveman). The proponent of this model, modestly labels it as the "preferred" opportunity cost model on grounds of both the soundness of its analysis and its susceptibility to empirical verification. Accepting the proposition that efficient public expenditures must demonstrate a social rate of return at least as great as that of the alternative spending which is sacrificed, the theory assumes that public expenditures are financed through taxes. Hence, it is the private spending which is displaced by these taxes which represents the opportunity cost of the public expenditures. Because the incidence of Federal taxes falls on both consumers and businesses, both consumption spending and investment spending get displaced. Thus, the social rate of discount must

reflect the private sector interest rates which govern both household consumption decisions (time preference) and business investment-borrowing decisions (rates of returns before taxes). Estimation of this rate requires that the bundle of Federal taxes be traced to its source in the various sub-sectors of the household and business sectors, and the observed interest rate in each of these sub-sectors be weighted by the relative amuont of spending displaced in each by the imposition of Federal taxes. The proper discount ate, then, is the value of private sector spending which is displaced because of taxes implicit in the public investment expenditure. According to Haveman's computation, this rate was equal to 7.3 percent for 1966. The author explained that this rate is two points higher than the 5.3 percent calculated for 1955 by Eckstein using the same model. The difference was due the data sources which were not available in 1957.

It would be hard, if not impossible to rerun Haveman's model using the latest data sources because many data are simply not readily available and numerous assmptions must be made based on one's judgment in order to compute the social rate of discount under the grand weighting schemes required by the model. But more important is the argument that correct discount rate could be correctly inferred from the exceptionally complicated structure of interest rates which can be observed in the market.

Eckstein 's Compromise. Eckstein (1958) offered a compromise which has considerable merit, although in 1968 testimony he appeared to move toward the opportunity cost arguments. Basically his compromise allows a low planning rate offset by a b/c cutoff to raise the yield of projects actually brought into the construction budget. At the time of his book, he derived a 6 percent opportunity cost to capital. He proposed a 3 percent planning rate and a 1.3 B/C rate cutoff or a 2.5 percent planning rate and a 1.4 percent cutoff to

produce an average rate of return to about 6 percent. This position would allow long-lived projects to be formulated and evaluated at the favorable rates.

VII. Summary of Discount Rate Estimates, Original and Updated

This section provides a summary of the original estimates and updated 1978 estimates of the discount rates reached by the various approaches reviewed earlier. Updated estimates for some of the opportunity cost models were not calculated because of the substantial effort that would be involved in recomputation.

Summary of Discount Rates

Model and Proponents		Original Estimates		Our Estimates for '78
Social Rate of Interest				
Marglin		N/A[1]		3-5 %
Arrow	Short-term rates[2]	5-8 %		5-10 %
Cost of Borrowing				
Treasury Bond Yields		4 5/8 %		7 5/8[3]
GAO		7.5 %		11 %
Opportunity Cost				
Seagraves (AAA Bonds)		8-13%[2]	('69)	8-10.5%
Stockfish (physical assets)		10.4%	('69)	N/A
Haveman (displaced private spending)		7.3%	('68)	N/A
Eckstein and Krutilla		6 %	('68)[4]	NA

1. Agencies would submit reports based on sensitivity runs of various rates

2. Adjusted for inflation, risk and institutional factors

3. OMB recently estimated cost of borrowing to be 13.5 percent.

4. Estimates in Eckstein's testimony before the 1968 Joint Economic Committee Hearings, see <u>Hearings</u>, p. 56. (See <u>Hearings, p. 56</u>).

Except for the procedure currently in practice, all other models have many practical problems in estimating the risk factor, tax impacts, inflation, and institutional factors for determining the discount rate. For instance tax impact analysis is particularly troublesome. According to one recent study based on reports by companies to the SEC, some of the Nation's largest companies paid practically no 1980 U.S. taxes by virtue of investment tax credit, foreign tax credit, and other tax provisions. The report concluded that the average tax rate paid by the 20 largest commercial banks (all but one of which had U.S. profits) was -0.9 percent. The study's findings simply indicate that it is extremely difficult to calculate the effective tax rates even for corporations filing returns with the SEC - not to mention the theoretical and practical difficulties of ascertaining the effective tax rates for individuals as a result of income tax changes. Several models of the opporunity cost variety make the claims of basing on "empirical data" or "susceptiblity of empirical verification" are, in fact based on incomplete and highly aggregate data with numerous ambiguous assumptions - and in many instances, on secondary sources of information.

One way of avoiding the interest rate controversy would be to change the evaluation rules to an internal rate of return basis. All projects generating non-discounted benefits would have a positive rate of return, however small. Such a policy would do away with the B/C analysis at a program-approved interest rate and, unless a higher rate of return was established as acceptable, none of the critics would be mollified.

In practice, the internal rate of return can also be faulted because it may not provide a unique optimal scale of development. Depending on the path of benefits and costs, several scales of development may generate the same rate of return.

VIII. Conclusion

The discount rate is crucial to project evaluation as it affects the capital intensity, the scale of development and the feasibility of public works projects. A higher discount rate would discourage large, capital intensive and long-lived projects in favor of small, less capital intensive and short-term projects. Application of a high discount rate to projects which, because of their technical nature, require large-scale development may lead to underdevelopment.

In theory, an ideal rate of discount when applied to all public and private investment decisions, would correctly allocate the resources of the Nation between public and private, and between present and future generations. Since such an ideal rate is not directly observable and available, various concepts and methods have been employed and inferences made in search for an appropriate rate of discount. We will comment on these diverse concepts briefly.

a. The social rate of interest model views the discount rate primarily as an allocater of investment between present and future generations. Arrow adds a new dimension to this concept by suggesting a dynamic programming format in which variable short-term interest rates, present and future options and the needs for a growing economy are considered simultaneously.

b. The present procedure uses the average yield on long-term Treasury Bonds as the discount rate. It is simple to use; however, the current trends since 1978 indicate that the Treasury is increasingly relying on short-term bonds and other instruments in the financial market as a way to finance deficits. As the Federal Reserve is reluctant to increase the money supply in fear of fueling inflation, the current competition between the Federal Government with private business for funds in the same market has caused the long-term bond market to deteriorate. While the implications of the new trends in Federal financing are unclear, the real interest rate (lowest risk and without inflation) has climbed from a long-run value of about 3 percent to 5-7 percent, in part due to the severe disruptions to savings and investment patterns resulting from persistant high inflation and unemployment.

c. The basic thrust of the opportunity cost models is that private investment is displaced by public investment and that the expected rate of return to the displaced private investment should be the basis for a properly designed rate of discount. Since the expected rate of return of a private enterprise reflects elements of risk, taxes, and inflation as well as a normal return to investment, various attempts have been tried for removing many effects to arrive at a real rate of return. A variant of the opportunity cost model is the belief that the effective interest rates facing individuals in various income tax classes corresponding to Government tax increases (or decreases) for financing project expenditure should be the basis for discounting.

The opportunity cost models appear to have the support of many economists who view the problem of selecting a discount rate to be the determination of the yields that alternative private investment can generate. This position, to

the degree that it is based on the notion that Government borrowing completely displaces private borrowing, is - to a substantial degree - faulty. The current Council of Economic Advisors has presented papers recently arguing that the displacement theory is not supported by empirical proof. In the meantime, the Nation is suffering from low productivity from human and natural resources. As pointed out by Marglin (1968), many Government investment projects complement rather than displace private investment and some Government investments represent re-investment of returns from previous investments.

Realizing the conceptual as well as the practical measurement problems of determining an appropriate discount rate as discussed earlier, the choices are: to mainain the status quo, to raise the present rate or to reduce it. The last option is ruled out in the present planning environment although the measured productivity in the U.S. economy (Abramovitz, 1981) and the rates of return for U.S. manufacturing corporations and non-financial corporations have been on the decline (Holland and Meyers, 1979) in recent years.

Maintaining the status quo would impose no burdens on planning. It would give the President and Congress flexibility in selection of projects according to the preferences of the decisionmakers.

A moderate increase in the present rate would be more in keeping with the current trends in interest rates and bond yields and with the reality that there is stiff competition for Federal funds for defense and other Federal programs. A rate higher than 10 percent has considerable appeal, but may be difficult to justify because: (1) the real rate of return, as seen in

Chart 1, was 7 or 8 percent on average for the past five years and (2) a higher rate would result in accentuating the inflation expectations and disrupt program planning.

An alternative to changing the present rate may be to raise the B/C ratio cutoff for above 1 for funding priority but to keep the present discount rate.

References

ARROW KENNETH J. and MORDECAI KURZ, Public Investment, the Rate of Return and Optimal Fiscal Policy Resources for the Future, Inc., The Johns Hopkins Press, Baltimore, 1970, 218 pp.

ARBRAMOVITZ, MOSES, "Welfare Quandaries and Productivity Concerns,"American Economics Review, March 1981, 218 pp.

BAUMOL, WILLIAM J., "On the Discount Rate for Public Projects, in Public Expenditures and Policy Analysis, ed. by Robert H. Haveman and Julius Margolis, Markham Economic Series, 1970. p. 274.

BEARD LEO R., Some Water Resource Policy Considerations, Water Supply and Management, Vol. 3. Pergamon Press, Ltd. Britain 1979. pp. 172-178.

BROOKINGS INSTITUTION, Problems in Public Expenditure Analysis, ed. by Samuel Chase, Jr. 1966.

ECKSTEIN, OTTO, Water Resources Development: The Economics of Project Evaluation, Harvard University Press, 1958. 301 pp.

HANKE, STEVE H. AND JAMES BRADFORD ANWYLL, "On the Discount Rate Controversy," Public Policy, Vol. XXVIII, Spring 1980.

HAVEMAN, ROBERT H., The Economics of the Public Sector, John Wiley and Sons, 1970.

HAVEMAN, ROBERT H., AND JULIUS MARGOLIS, Public Expenditures and Policy Analysis, Markham Economic Series, 1971.

HAVEMAN, ROBERT H., The Opportunity Cost of Displaced Private Investment, in Water Resources and Economic Development of the West. pp. 25-49.

HOLLAND, DANIEL M. AND STEWARD C. MYERS, "Profitability and Capital Costs for Manufacturing Corporations and All Non-financial Corporations," American Economy Review, Papers and Proceedings, 92nd Meeting, 1979, pp. 320-325.

JOHN V. KRUTILLA AND OTTO ECKSTEIN, Multiple Purpose River Development, Resources for the Future, Inc., Johns Hopkins Press, Baltimore 1958. 301 pp.

MARGLIN, STEPHEN A., The Discount Rate in Public Investment Evaluation, in Water Resources and Economic Development of the West, pp.71-82, Western Agricultural Economic Research Council, Denver, Colorado, 1968.

MISHAN, E. J., Cost-Benefit Analysis, Praeger Special Studies, N.Y. 1976.

MUSHKIN, SELMA, ED., Public Prices for Public Products, The Urban Institute,Washington, D.C. 1972.

SEAGRAVES, J. A., "More on the Social Rate of Discount,"Quarterly Journal of Economics, Vol 84, 1970.

The Comptroller General of the United States, Report to Congress, "Reforming Interest Provisions in Federal Water Laws Could Save Millions," CED 82-3, Oct. 22 1981.

U.S. CONGRESS, 90th Congress, 2nd Session, "Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis," Hearings before the Joint Economic Committee, 1968.

U.S. NATIONAL WATER COMMISSION, Water Policies for the Future," June 1973, pp. 383-387.

ILLUSTRATION OF CALCULATION OF TOTAL COST

TO THE GOVERNMENT OF BORROWED FUNDS

METHOD I

The current interest cost of borrowing long-term money is approximately 5 percent. The moving average rate specified by Senate Document 97 is currently about 3.2 percent. Therefore, a rate of interest approximately halfway between 5.0 and 3.2 could be used for initial consideration as the Government cost of borrowed money.	4.0%
Add to this cost:	
1. Corporate taxes foregone by the Government if the average corporate return on investment is 12 percent before taxes[1], if the fraction of dollars borrowed by the Government which would have gone into corporate investment is 65 percent[2], and if the marginal corporate tax rate is 40 percent.	
(.12) (.65) (.4)	3.1%
2. Personal taxes foregone by the Government if the average return on proprietorship, personal income-producing investments, etc., is such that the remaining 35 percent of money borrowed by the Government would have earned a 10-percent return for the persons taxed, and if such return would be taxed at a composite marginal rate of 20 percent.[3]	
(.1) (.35) (.2)	[illegible].0%
3. (a) Taxes foregone by the Government on dividends that would have been received by individuals from corporations if the composite marginal tax rate applicable to individuals is 20 percent, if the taxable dividends payout is 40 percent of corporate	

profits after taxes, and if the assumptions as to corporate earnings and the marginal tax rate shown above under (1) are applicable. The marginal corporate tax rate is assumed to be 40 percent therefore 60 percent of corporate earnings is assumed available to the corporation for payment of dividends.

(.3) (.4) (.12) (.65) (.6) = .6%

(b) Personal taxes foregone by the Government if the corporate investment is financed by bonds rather than by corporate earnings, if corporate bonds carry an interest rate of 5 percent, if the fraction of dollars borrowed by the Government which would have gone into corporate investment is 65 percent, and if the composite marginal tax rate applicable to individuals is 30 percent.

(.05) (.65) (.3) = 1.0%

(c) Actual overall financing arrangements by corporations will generate tax revenues under both (a) and (b), therefore the cost to the Government may be assumed to be somewhere between .6 percent and 1.0 percent, say about .8%

Subtract from this cost:

1. Income taxes collected on Government interest payments, if investment in bonds (see rate above of 4 percent) are divided between corporations and individuals in such a way that the tax rate is 35 percent.

(.04) (.35) -1.4%

Cost to Government 7.5%

METHOD II

On an aggregate basis, a similar result may be computed assuming a composite corporate and personal marginal tax rate of 50 percent[2] and a taxable return of 10 percent on any money not borrowed by the Government.

(.5) (.1)	5.0%
Cost of Government borrowing (see explanation under Method I)	4.0%
Less taxes on Government bond interest (.04) (.35) (see explanation under Method I)	-1.4%
Cost to Government	7.6%

---

[1]Various economists have examined rates of return before taxes in the private sector. Stockfisch (see footnote on page 7), arrives at an average of 13.5 percent. Stiegler, National Bureau of Standards, determines a rate of 14 percent. Variations in this estimate result from consideration of differing time periods, weighting, etc. Our estimate of 12 percent used for this appendix is somewhat conservative in comparison with the recent experience noted by these economists.

[2]See Raymond Goldsmith's "Flow of Capital Funds in the Post-war Economy," National Bureau of Economic Research, 1965, where a table of gross capital consumption by major segments of the economy is shown. We are interested here in capital consumption for purposes of productive investment. Most household borrowing can be excluded as investment in consumption which would also result from payments by the Government to labor involved in Government programs. State and local capital consumption can be left out of this consideration. The corporate share of the remainder is approximately 65 percent.

[3]A table of marginal tax rates for various income levels is contained in a study done by the Institute for Defense Analyses for the Office of Economic Opportunity, as

summarized in "R-116, Federal Poverty Program, Assessment and Recommendations," January 1966. This document shows that the average marginal rate is approximately 30 percent for the higher income levels, from which personal income-producing investments tend to originate.

[4] This is a rough composite marginal rate for corporate and personal taxpayers that provides approximately for the separate estimates shown in 1, 2, and 3 for Method I.

As the following table illustrates, the Treasury's borrowing costs have been steadily on the rise, with the March 1981 Treasury rate at 13.12 percent.

U.S. Treasury Constant
Maturity Yield Rates
(1958-81) (note a)

Year	Rate	Year	Rate	Year	Rate
1958	3.32	1966	4.92	1974	7.56
1959	4.33	1967	5.07	1975	7.99
1960	4.12	1968	5.65	1976	7.61
1961	3.88	1969	6.67	1977	7.42
1962	3.95	1970	7.35	1978	8.41
1963	4.00	1971	6.16	1979	9.44
1964	4.19	1972	6.21	1980	11.46
1965	4.28	1973	6.84	1981 (Mar.)	13.12

a/Department of the Treasury, Board of the Federal Reserve System Capital Market Rates.

No. 907. Bond Yields, Stock Yields, and Mortgage Rates: 1960 to 1979

[Percent per year. Annual averages of monthly data, except as indicated. See also *Historical Statistics, Colonial Times to 1970*, series X 474-491]

TYPE	1960	1965	1970	1972	1973	1974	1975	1976	1977	1978	1979
U.S. Treasury, constant maturities [1]											
1 year	3.98	4.22	7.29	5.72	6.95	7.82	7.49	6.77	6.09	8.29	9.71
5 year	4.09	4.25	7.38	5.98	6.87	7.80	7.77	7.18	6.99	8.32	9.52
10 year	4.12	4.28	7.35	6.21	6.84	7.56	7.99	7.61	7.42	8.41	9.44
20 year	4.06	4.27	6.86	6.01	7.12	8.05	8.19	7.86	7.67	8.48	9.33
U.S. Govt., 3-5 year issues [2]	3.99	4.22	7.37	5.85	6.92	7.81	7.55	6.94	6.85	8.30	9.58
U.S. Govt., long term bonds [2,3]	4.01	4.21	6.59	5.63	6.30	6.99	6.98	6.78	7.06	7.89	8.74
State and local govt. bonds, Aaa [4]	3.26	3.16	6.12	5.04	4.99	5.89	6.42	5.66	5.20	5.52	5.92
State and local govt. bonds, Baa [4]	4.22	3.57	6.75	5.60	5.47	6.53	7.62	7.49	6.12	6.27	6.73
High-grade municipal bonds (Standard & Poor's) [5]	3.73	3.27	6.51	5.27	5.18	6.09	6.89	6.49	5.56	5.90	6.39
Municipal (Bond Buyer, 20 bonds)	3.52	3.27	6.35	5.26	5.19	6.17	7.05	6.64	5.68	6.03	6.52
Corporate Aaa seasoned [4]	4.41	4.49	8.04	7.21	7.44	8.57	8.83	8.43	8.02	8.73	9.63
Corporate Baa seasoned [4]	5.19	4.87	9.11	8.16	8.24	9.50	10.61	9.75	8.97	9.49	10.69
Corporate Aaa utility bonds [6]	4.73	4.57	8.72	7.37	7.67	9.01	9.17	8.46	8.12	8.90	9.82
Corporate, by years to maturity [7] 5 yr	4.73	4.29	8.10	6.50	6.85	7.47	7.70	7.56	7.25	7.75	9.40
10 yr	4.60	4.33	8.00	7.05	7.05	7.62	8.00	8.18	7.60	7.98	9.25
20 yr	4.55	4.35	7.60	7.05	7.20	7.80	8.35	8.30	7.75	8.20	9.08
30 yr	4.55	4.37	7.60	7.01	7.20	7.80	8.35	8.30	7.95	8.25	9.10
Corporate (Moody's)	4.73	4.64	8.51	7.63	7.80	9.03	9.57	9.01	8.43	9.07	10.12
Industrial (40 bonds) [4]	4.59	4.61	8.26	7.35	7.60	8.78	9.25	8.84	8.28	8.90	9.85
Railroads (21 bonds)	4.92	4.72	8.77	7.99	8.12	8.98	9.39	8.85	8.13	8.64	9.60
Public utilities (40 bonds)	4.69	4.60	8.68	7.74	7.83	9.27	9.88	9.17	8.58	9.22	10.39
Stocks (Standard & Poor's) [5]											
Preferred (10 stocks) [8]	4.75	4.33	7.22	6.88	7.23	8.24	8.36	7.90	7.61	8.25	9.11
Common: Composite (500 stocks)	3.47	3.00	3.83	2.84	3.06	4.47	4.31	3.77	4.62	5.28	5.47
Industrials (400 stocks)	3.36	2.94	3.62	2.61	2.79	4.13	3.96	3.48	4.43	5.06	5.20
Home mortgages: [9]											
FHA insured, secondary market	6.16	5.47	9.03	7.53	8.19	9.55	9.19	8.92	8.68	9.70	10.87
Conventional, new-home [10]	(NA)	5.83	8.52	7.64	8.30	9.22	9.10	8.99	8.95	9.68	11.15
Conventional, existing-home [10]	(NA)	5.83	8.56	7.70	8.33	9.23	9.14	9.04	9.00	9.70	11.16

NA Not available. [1] Yields on the more actively traded issues adjusted to constant maturities by the U.S. Treasury, based on daily closing bid prices. [2] Unweighted averages for all outstanding notes and bonds in maturity ranges shown, based on daily closing bid prices. [3] Includes all bonds neither due nor callable in less than 10 years. [4] Source: Moody's Investors Service, New York, N.Y. [5] Source: Standard & Poor's Corp., New York, N.Y., *Standard & Poor's Outlook*, weekly. [6] Averages based on first trading day of each month, deferred call, new issue estimate. Source: Salomon Brothers, New York, N.Y., *An Analytical Record of Yields and Yield Spreads*. [7] Source: Scudder, Stevens & Clark, New York, N.Y., unpublished data. [8] Prior to Sept. 9, 1965, yields based on 14 stocks, 8 yields; thereafter, 10 stocks, 4 yields. Issues converted to a price equivalent to $100 par and a 7 percent annual dividend before averaging. [9] Averages based on quotations for 1 day each month as compiled by FHA. [10] Primary market.

Source: Except as noted, Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin*, monthly.

No. 908. Sales of Stocks and Options on Registered Exchanges: 1960 to 1979

[See also *Historical Statistics, Colonial Times to 1970*, series X 517-530]

EXCHANGE	UNIT	1960	1965	1970	1973	1974	1975	1976	1977	1978	1979
ALL EXCHANGES											
Market value, all sales [1]	Bil. dol.	47	93	136	187	125	167	203	190	269	324
Stocks: [2] Market value	Bil. dol.	45	89	131	179	118	157	195	187	249	300
Shares	Mil.	1,389	2,587	4,539	5,723	4,846	6,201	7,036	7,023	9,403	10,863
Options: Market value	Mil. dol.	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	7,919	10,899	18,951	22,025
Contracts	Mil.	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	23	40	60	65
Rights and warrants:											
Market value	Mil. dol.	75	305	576	984	394	295	258	190	346	755
Number of units	Mil.	51	62	295	176	104	150	89	112	82	115
Option exercises: Value	Mil. dol.	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	2,872	3,606	5,292	8,301
Shares	Mil.	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	1	1	1	2
NEW YORK STOCK EXCHANGE											
Market value, all sales [1]	Bil. dol.	40	77	108	155	106	143	165	157	211	252
Stocks: [2] Market value	Bil. dol.	38	73	103	146	99	134	165	157	210	251
Shares	Mil.	958	1,609	3,213	4,337	3,822	5,056	5,649	5,613	7,618	8,675
Rights and warrants:											
Market value	Mil. dol.	13	34	257	348	182	100	133	89	124	484
Number of units	Mil.	29	58	233	84	63	108	53	62	42	84
Sales by size [3]											
At 100 shares	Percent	(NA)	(NA)	51.7	46.4	45.3	41.4	38.1	35.6	32.0	31.6
At 200-900 shares	Percent	(NA)	(NA)	40.7	44.5	45.7	47.8	49.2	49.7	50.1	49.8
At 1,000 shares and over	Percent	(NA)	(NA)	6.4	9.1	9.0	10.8	12.7	14.6	17.0	18.6

NA Not available. [1] Includes bond sales through 1975, not shown separately. [2] Includes voting trust certificates, American depositary receipts, and certificates of deposit for stocks. [3] Sales printed on New York Stock Exchange. Source: New York Stock Exchange, Inc., New York, N.Y., *Fact Book*, annual.

Source: Except as noted, U.S. Securities and Exchange Commission. Monthly data in *Statistical Bulletin*.

TABLE 1—ESTIMATED REAL RATES OF RETURN FOR MANUFACTURING CORPORATIONS AND ALL NONFINANCIAL CORPORATIONS, 1946–78

(Shown in Percent)

	Manufacturing				All Nonfinancial			
Year	Return to Investors	After-Tax Return on Capital	Effective Tax Rate	Before-Tax Return on Capital	Return to Investors	After-Tax Return on Capital	Fffective Tax Rate	Before-Tax Return on Capital
1947	−0.6	9.4	55.7	16.8	−5.1	7.0	52.1	14.6
1948	2.5	9.6	44.6	17.7	2.2	9.0	44.2	16.1
1949	18.3	10.1	37.9	16.1	17.1	8.4	38.7	13.7
1950	28.7	8.3	58.2	20.1	17.7	7.2	55.4	16.1
1951	20.9	7.7	63.4	21.0	13.0	6.3	61.5	16.2
1952	16.9	7.0	57.7	16.5	14.7	5.9	56.5	13.6
1953	−2.5	6.3	61.3	16.1	−0.7	5.2	59.3	12.7
1954	56.9	6.6	52.9	14.0	42.6	5.7	51.7	11.9
1955	34.9	8.7	52.8	18.5	24.4	7.3	50.8	14.8
1956	4.7	7.0	53.9	15.2	1.9	5.9	53.2	12.7
1957	−13.5	6.5	52.4	13.7	−10.6	6.0	51.3	11.5
1958	39.6	5.1	51.0	10.4	33.8	5.0	49.4	9.8
1959	10.8	7.8	49.5	15.5	8.3	6.4	48.4	12.4
1960	−2.6	7.2	48.5	13.9	0.3	6.1	46.9	11.4
1961	25.2	6.8	49.5	13.4	22.1	6.0	47.2	11.4
1962	−10.5	8.9	44.8	15.7	−7.3	7.7	41.7	13.1
1963	21.2	9.5	45.0	17.3	16.7	8.2	41.6	14.0
1964	14.8	10.8	42.1	18.8	13.1	9.3	38.7	15.2
1965	10.6	12.6	41.4	21.5	8.2	10.3	37.6	16.5
1966	−13.1	12.5	41.3	21.4	−11.6	10.2	37.5	16.3
1967	20.9	10.7	39.5	17.6	14.7	9.1	36.5	14.3
1968	5.2	9.7	44.8	17.6	4.7	8.3	40.9	14.1
1969	−13.6	7.8	46.1	14.5	−14.5	7.2	41.9	12.4
1970	−0.1	5.8	43.1	10.1	1.7	5.9	39.8	9.8
1971	11.0	6.3	43.6	11.2	10.1	6.2	39.0	10.1
1972	14.5	7.8	41.5	13.4	12.4	7.1	36.8	11.2
1973	−20.8	7.0	46.3	13.1	−19.7	6.5	40.0	10.9
1974	−31.4	2.7	66.4	8.0	−31.9	4.3	47.9	8.2
1975	22.8	5.3	39.7	8.7	21.4	5.5	37.7	8.8
1976	16.9	6.3	43.7	11.2	17.4	5.8	40.0	9.7
1977	−12.9	6.7	43.8	12.0	−11.7	6.1	39.8	10.1
1978	−3.3	6.7	44.0	11.9	−4.7	6.0	41.0	10.2
1947–50	12.2	9.4	49.1	17.7	8.0	7.9	47.6	15.1
1951–54	23.1	6.9	58.8	16.9	17.4	5.8	57.2	13.6
1955–58	16.4	6.8	52.5	14.5	12.4	6.1	51.2	12.2
1959–62	5.7	7.7	48.1	14.6	5.9	6.6	46.1	12.1
1963–66	8.4	11.4	42.5	19.8	6.6	9.5	38.9	15.5
1967–70	3.1	8.5	43.4	15.0	1.7	7.6	39.8	12.7
1971–74	−6.7	6.0	49.5	11.4	−7.3	6.0	40.9	10.1
1975–78	5.9	6.3	42.8	11.0	5.6	5.9	39.6	9.7
Average for the Period 1947–78								
Mean	8.5	7.9	48.3	15.1	6.3	6.9	45.2	12.6
Standard Deviation	18.8	2.1	7.3	3.6	15.8	1.5	7.2	2.4

SOURCE:
The American Economic Review, Papers and Proceedings, May 1980, page 321

THE EFFECT OF INTEREST RATES ON THE ECONOMIC ANALYSIS OF THE GREGORY COUNTY PUMPED STORAGE FACILITY

Chrisopher P. Knievel, Economist
Omaha District

THE EFFECT OF INTEREST RATES ON THE ECONOMIC ANALYSIS

OF THE GREGORY COUNTY PUMPED STORAGE FACILITY

As a rule raising the discount rate under which a project alternative is analysed has an adverse effect on the feasibility of the alternative, i.e. an alternative viable at a low rate may not be viable at a high rate. The primary reason for this is that benefits are essentially fixed while annual costs increase because of higher interest during construction and/or amortization of the project costs.

Hydropower projects are an exception to this rule because of the way project benefits are determined. This can be demonstrated using the economic analysis of the Gregory County Pumped Storage Facility which is proposed by the Omaha District.

The proposed site is located on the left bank of the Missouri River in Gregory County, South Dakota as shown in Figure 1. The forebay of the project would be on the plateau about 600 feet above the surface of the afterbay, Lake Francis Case. Peaking power from the project would be supplied to the Midcontinent Area Power Pool (MAPP.) Total capacity would be 2360 MW.

The project would be built in two stages of 1,180 MW each as shown in Table 1. This was done to reduce interest during construction and better match the forecast need for peaking power in MAPP. The total cost of the project in 1982 dollars would be $1,842,891,000.

FIGURE 1

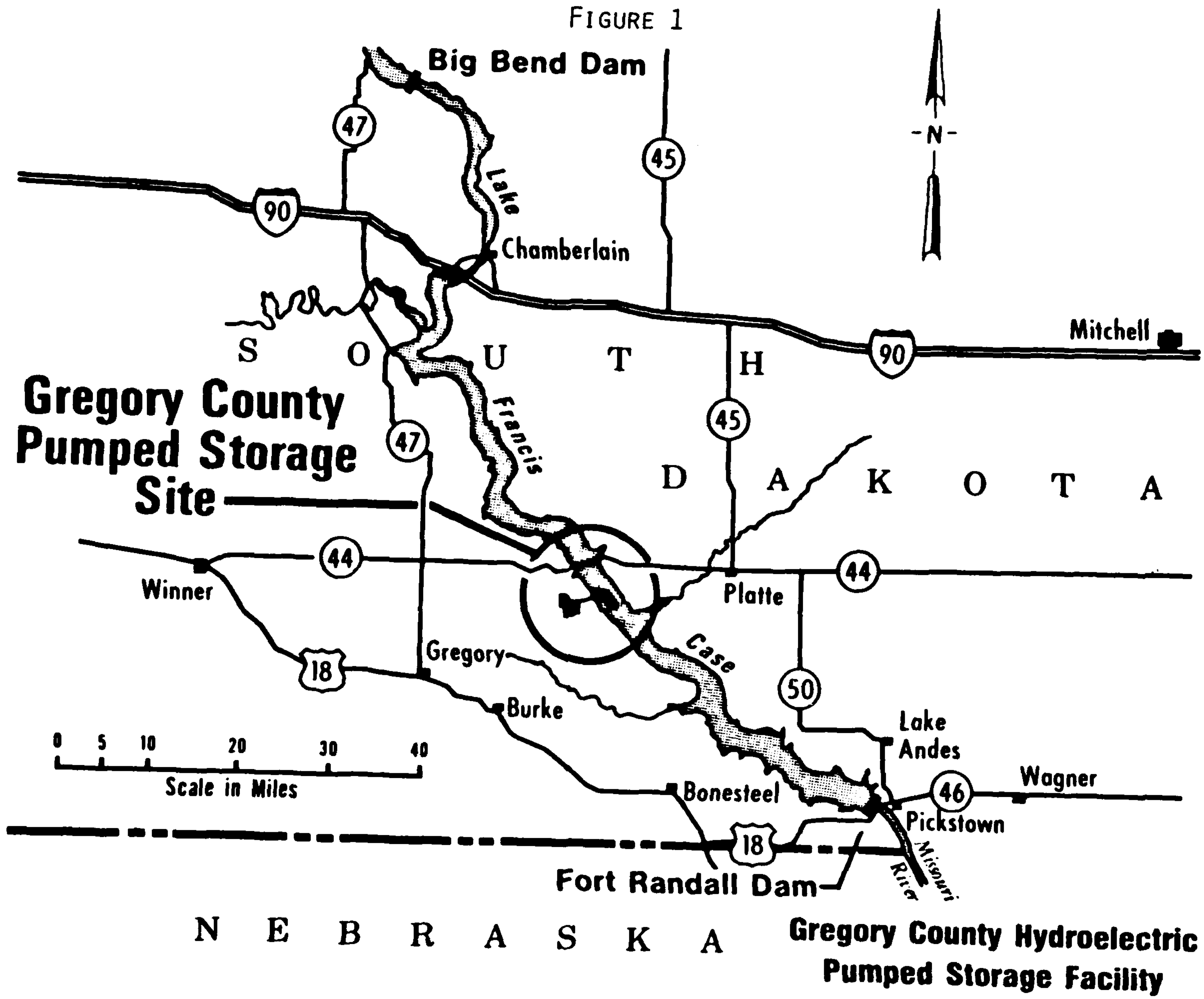

Big Bend Dam
Lake
Chamberlain
Francis
Case
Mitchell
-N-
S O U T H D A K O T A
Gregory County Pumped Storage Site
Winner
Gregory
Burke
Bonesteel
Platte
Lake Andes
Wagner
Pickstown
Missouri River
Fort Randall Dam
0 5 10 20 30 40
Scale in Miles
N E B R A S K A
Gregory County Hydroelectric Pumped Storage Facility
90
47
45
44
18
50
46

TABLE 1

GREGORY COUNTY INVESTMENT COSTS ($000)

	Stage 1	Stage 2	Total
1985	$ 3,117		$ 3,117
1986	9,834		9,834
1987	62,278		62,278
1988	153,876		153,876
1989	159,932	$ 2,240	162,172
1990	231,317	15,232	246,549
1991	117,402	91,056	208,458
1992	40,109	151,394	191,503
1993		159,963	159,963
1994		112,995	112,995
1995		102,537	102,537
1996	--------	78,689	78,689
Total	$777,865	$714,106	1,491,971
Interest During Construction at 7 5/8%	172,792	167,265	340,057
Mitigation	10,863	-------	10,863
Total Cost	$961,520	$881,371	$1,842,891

Total investment costs of Stage 1 would be $961,520,000 as shown in Table 2. (Since the economic analysis of both

TABLE 2

SUMMARY OF STAGE 1 ANNUAL COSTS ($000)

Total Investment Costs	$961,520
Annual Interest and Amortization	75,224
Annual M&R	1,711
Annual Pumping Cost	
Unescalated	35,350
Escalated	65,384
TOTAL ANNUAL COST	
Unescalated	$112,285
Escalated	$142,319

Stage 1 and Stage 2 are almost the same only Stage 1 will be discussed for the sake of simplicity.) Annual interest and amortization over 50 years at 7.625 percent would be $75,224,000 and annual M&R would be $1,711,000.

Annual pumping costs are the energy which is used during off peak hours to pump the water into the forebay. Two costs are shown. The first, $35,350,000, is the cost in 1982 dollars without forecast increases in the real price of electricity produced by coal-fired plants. The second cost, $65,384,000 does take forecast increases into account. It is simply $35,350,000 multiplied by 1.85, the real fuel cost escalation factor for coal. The real fuel cost escalation factor was calculated using the compound annual real fuel price escalation shown in Table 3. Coal is compounded forward to the end of the project life and then discounted back to the first year of project operation using the project's interest rate, 7.625

TABLE 3

COMPOUND ANNUAL

REAL FUEL PRICE ESCALATION

TIME INTERVAL	ANNUAL INCREASE IN PERCENT OF REAL FUEL COST	
	OIL	COAL
1980-1985	3.38	9.55
1985-1990	2.93	1.66
1990-2010	4.12	0.61
2010-2030	0	0

percent. Thus, the real fuel cost escalation factor can

change because of the interest rate and the timing of the project life.

There are two total annual costs for Stage 1. The first, $112,285,000 is based on unescalated annual pumping costs while the second, $142,319,000 is based on real fuel cost escalation.

Table 4 summarizes the annual benefits of Stage 1. The annual capacity benefits is essentially the annual interest and amortization of the oil and coal-fired alternatives, $29,512,000 and $165,047,000 respectively. Because coal-fired plants are relatively expensive to build their annual cost is high while that of oil is low.

TABLE 4

SUMMARY OF STAGE 1 ANNUAL BENEFITS ($000)

Annual Capacity Benefits	$ 29,512	$165,047
Annual Energy Benefits		
Unescalated	66,466	40,893
Escalated	152,875	75,652
Total Annual Hydropower Benefits		
Unescalated	$ 95,978	$205,940
Escalated	$182,387	$240,699

There are two sets of annual energy benefits, unescalated oil and coal and escalated oil and coal. The unescalated energy benefits are the energy costs of oil- and coal-fired plant operation without forecast real price increases for oil and coal. The escalated energy benefits assume real fuel cost escalation and are the unescalated benefits multiplied by

factors, by 2.3 for oil and 1.85 for coal. How these were calculated was discussed above. Thus, four annual energy benefits and total annual hydropower benefits are shown.

TABLE 5

STAGE 1 BENEFIT-COST ANALYSIS ($000)

Annual Net Benefits		
Unescalated	$-16,307	$ 93,655
Escalated	$ 40,068	$ 98,380
Benefit to Cost Ratios		
Unescalated	.9	1.8
Escalated	1.3	1.7
IRR		
Unescalated	6.41	16.23
Escalated	11.89	16.58
Net Present Value		
Unescalated	$-85,532	$751,741
Escalated	$343,598	$787,611

Table 5 shows the Stage 1 benefit-cost analysis. Annual net benefits are all positive except for unescalated oil which in any case is the least likely alternative. Escalated coal, the most likely alternative, is the highest. The benefit to cost ratios show the same relationship except that unescalated coal has the highest B-C ratio. Except for unescalated oil the internal rates of return are all above the discount rate. Finally the net present values are all positive except for unescalated oil. Thus on the basis of the most likely alternative, escalated coal, and two of the other alternatives the

project is feasible at the authorized interest rate of 7.625 percent.

Figure 2 shows how the B-C ratios change with the discount rate. Those of unescalated and escalated oil behave as one might expect in that they drop below 1 in the range of rates between 3 and 16.25 percent (3 percent, approximately the real rate of interest, 7.625 percent; the authorized rate at that time; 10.1 percent, the FERC composite rate; 14.5 percent, the Treasury 30 year rate at that time; and 16.35 percent, the AAA utility rate at that time). The unescalated and escalated coal ratios, however, remain about the same over the range and are feasible even at 16.25 percent.

Figure 3 shows the annual net benefits at various discount rates. Again those of oil drop throught the range. Those of coal, however, do not drop but rise through the range.

Figure 4 shows the net present values. Again those of oil drop to below $0. Those of coal also decrease but do not approach $0 in the range.

Finally, figure 5 shows the IRRs at various interest rates. In this case the IRRs of both coal and oil increase or are flat over the range. What is more interesting is that the IRRs change at all since it is defined as the interest rate at which the present value of the stream of negative (costs) and positive (benefits) cash flows equal 0. Obviously, the method used for calculating the IRRs was not correct.

FIGURE 2

STAGE 1 B-C RATIOS AT VARIOUS INTEREST RATES

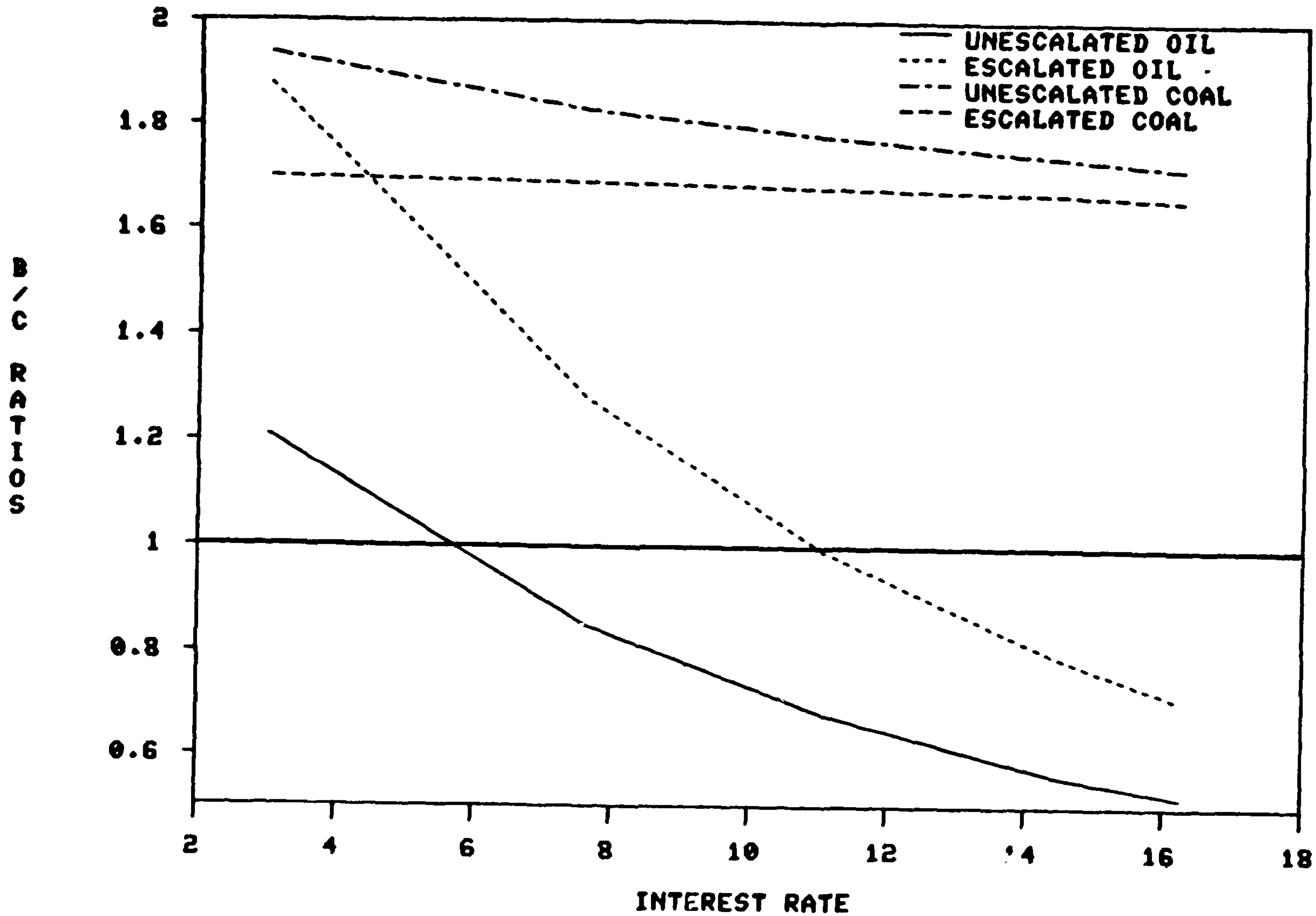


Figure 3

STAGE 1 ANNUAL NET BENEFITS AT VARIOUS INTEREST RATES

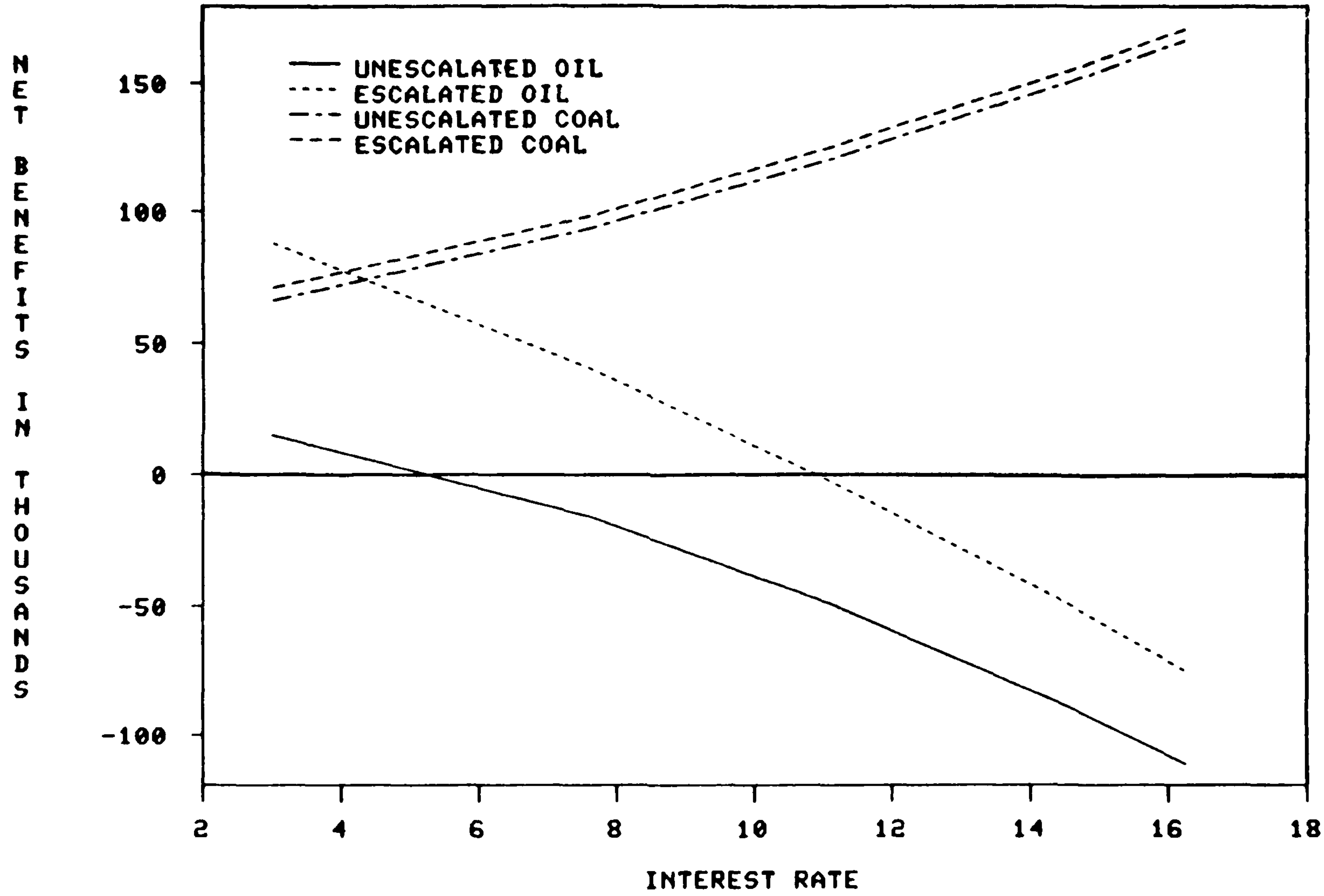


FIGURE 4

STAGE 1 NPVS AT VARIOUS INTEREST RATES

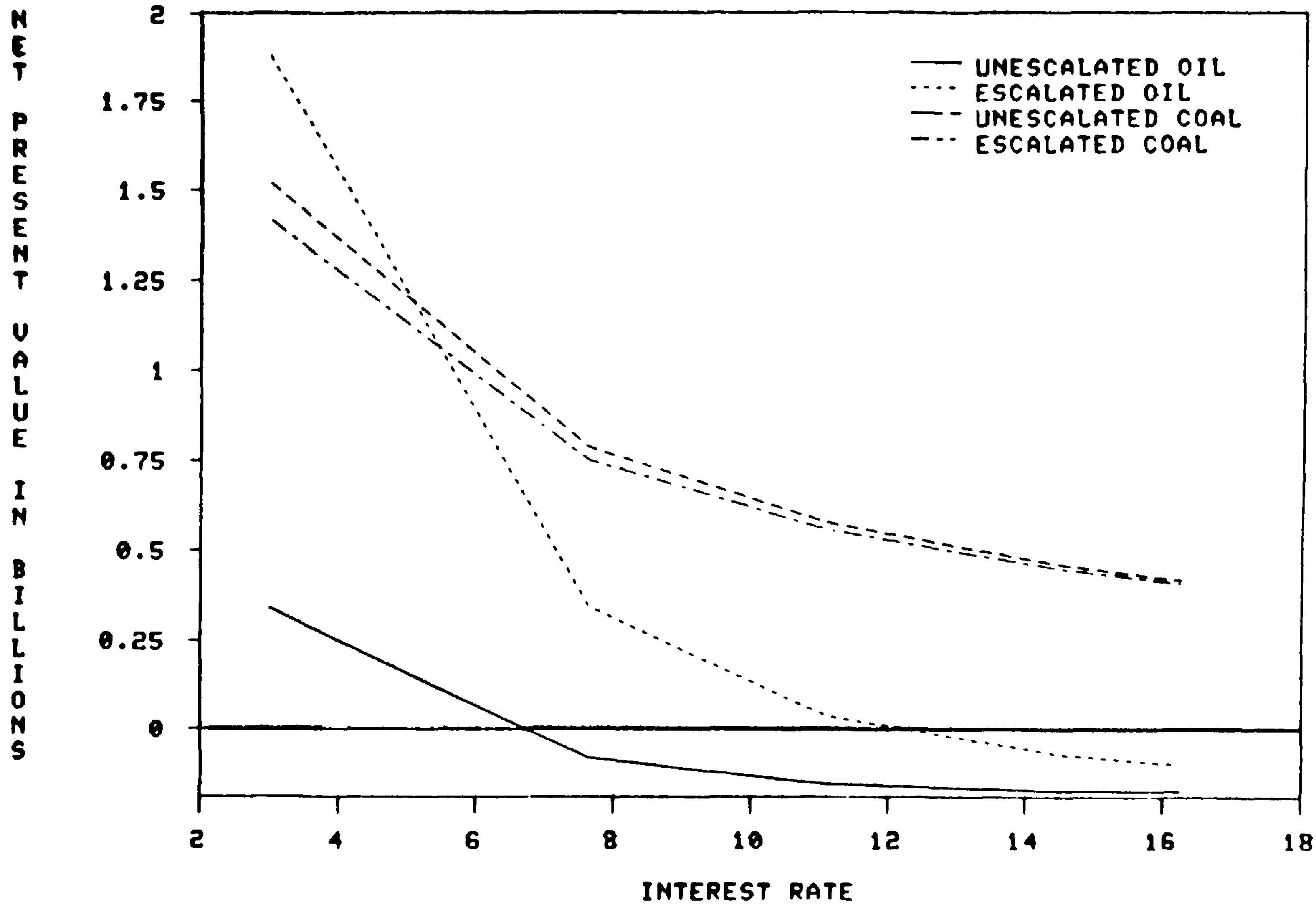


FIGURE 5
STAGE 1 IRRS AT VARIOUS INTEREST RATES

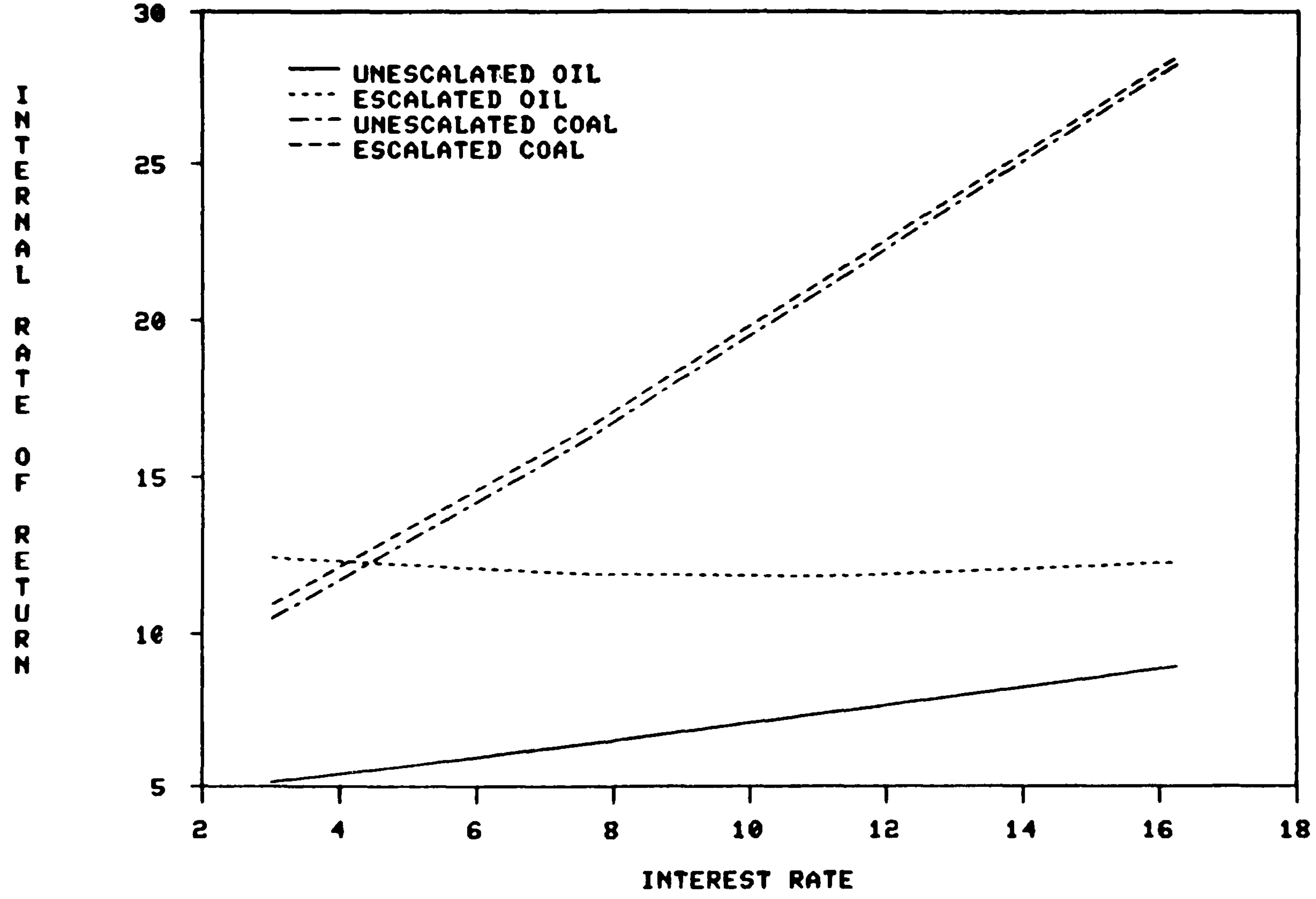


TABLE 6

STAGE 1

REAL FUEL COST ESCALATION FACTORS

INTEREST RATE	OIL	COAL
3	2.57	1.88
7.625	2.30	1.85
11.1	2.14	1.83
14.5	2.03	1.81
16.25	1.98	1.81

Why did the annual net benefits, the B-C ratios, the net present values, and IRRs change over the range? They changed because both the costs and benefits changed with the interest rate. On the cost side the annual interest and amortization increased with the interest rate because of the higher IDC and amortization factors. The unescalated pumping cost does not change but the escalated pumping cost, which is based on coal, decreases slightly. This is shown in Table 6.

On the benefits side the capacity benefits increase because of the IDC and amortization factors of oil and coal fired plants. This is shown in Table 7. Coal in particular

TABLE 7

STAGE CAPACITY FACTORS

INTEREST RATE	OIL	COAL
3.0	.63	.58
7.625	1.00	1.00
11.1	1.32	1.41
14.5	1.65	1.89
15.25	1.82	2.17

increases substantially because of the magnitude and timing of construction costs.

Unescalated energy benefits remain the same and escalated energy benefits decline with the interest rate as was shown in Table 6.. Coal declines only slightly because the major real cost increases are near term. Oil drops substantially because the largest cost increases are more far term. Thus, when the various measures are computed costs and benefits both increase substantially. In the case of coal annual costs increase less than annual benefits so negative annual net benefits are not calculable in the range and probably above.

To calculate a valid IRR and NPV a different approach should be used. This entails taking the previously presented data and stripping the interest rates from the analysis so only the actual cash flows are left. The cash flows for Stage 1 and the coal fired alternative are shown in figure 6. The top of the figure shows the negative cash flows (the costs of building and operating Stage 1). The bottom shows the positive cash flows (the cost of building and operating the coal-fired alternatives). Since the economic life of a coal-fired plant is only 30 years a replacement would have to be built during the period. Figure 7 shows the net cash flows of Stage 1. Except for a brief period of project construction the cash flows are all positive. It also shows that the coal-fired alternative is more expensive than the pumped storage facility to build and its initial cash flows are quite high.

FIGURE 6

UNESCALATED GREGORY COUNTY STAGE 1 CASH FLOWS ($000)

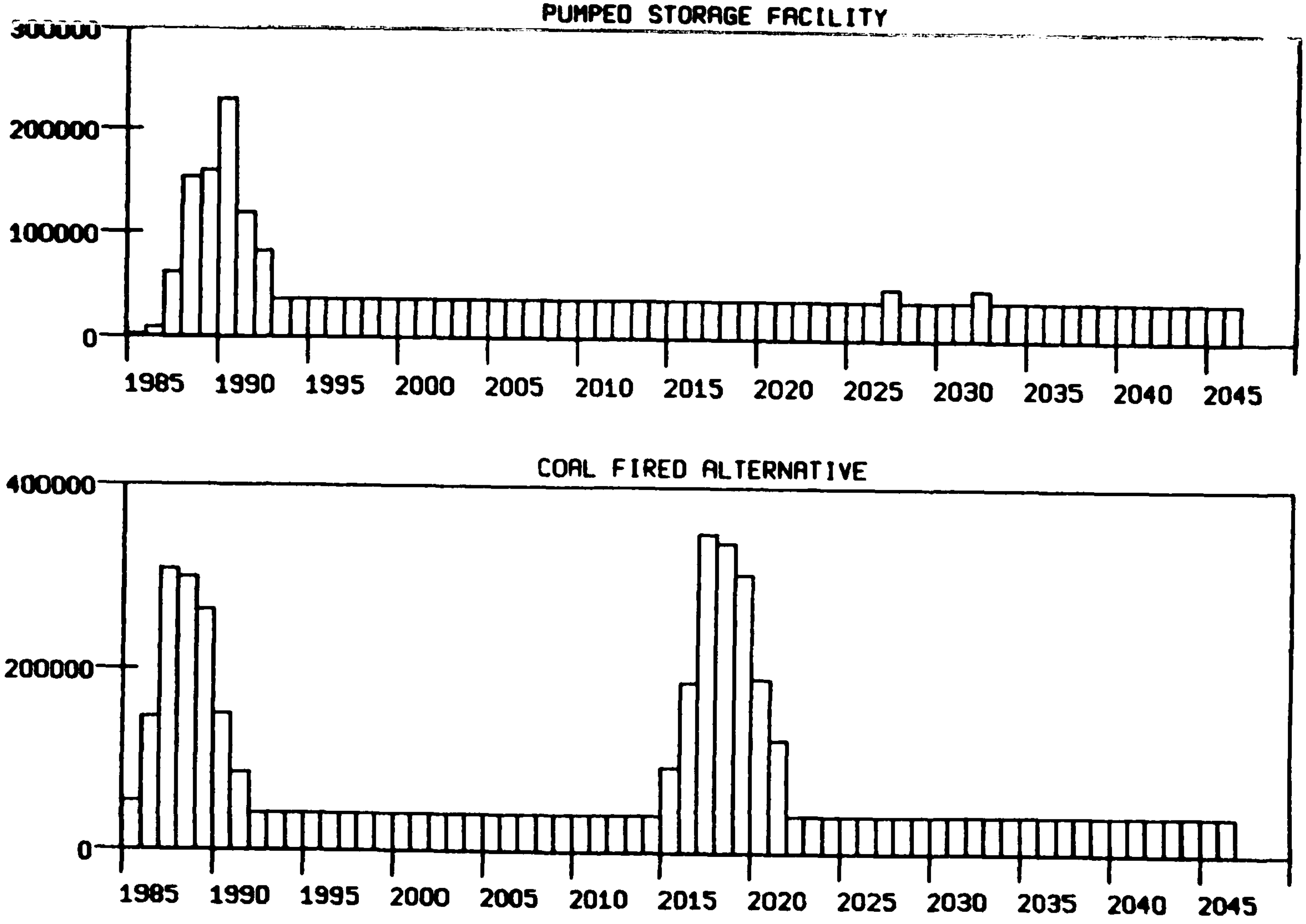
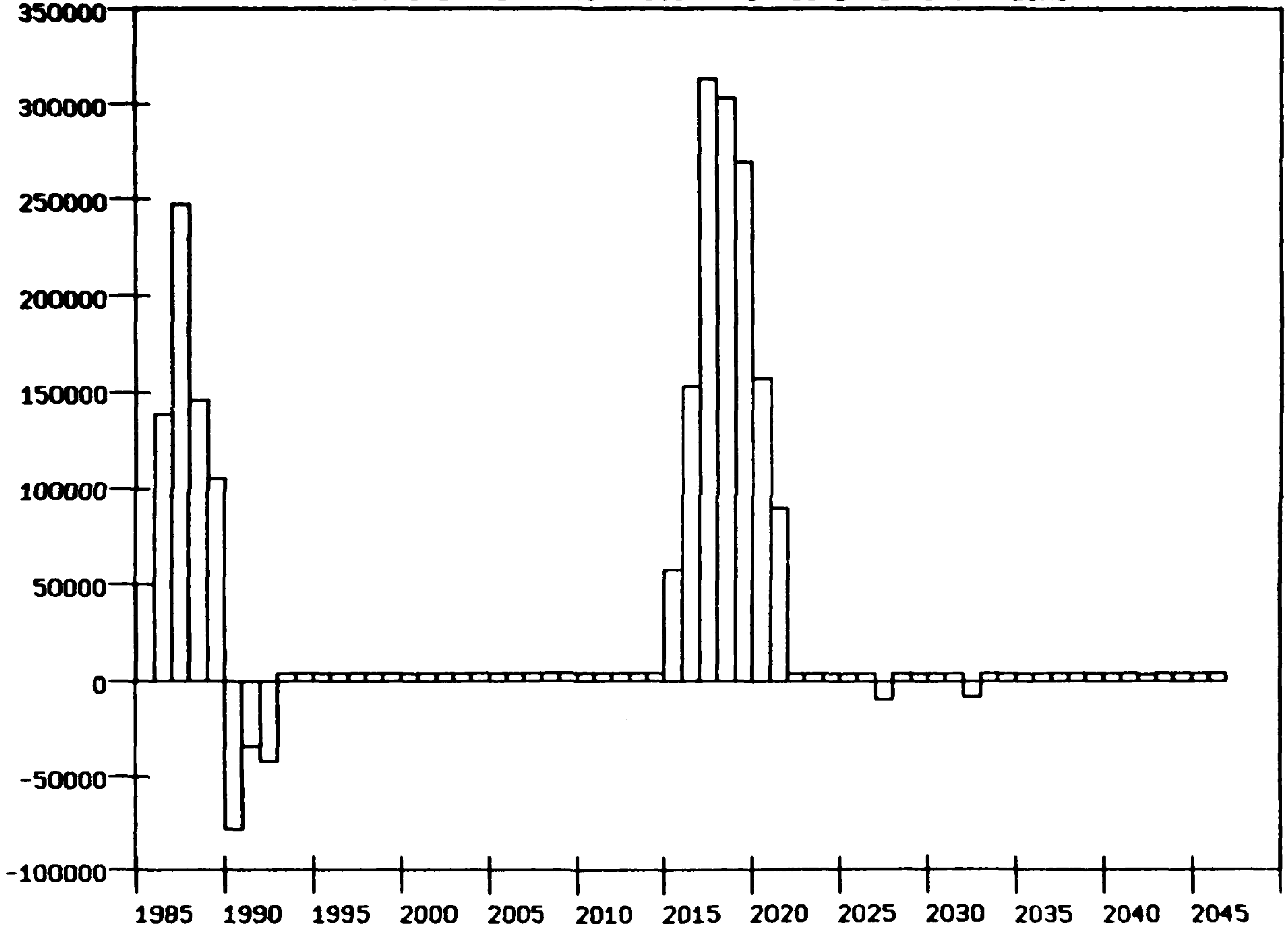


FIGURE 7

UNESCALATED GREGORY COUNTY STAGE 1 NET CASH FLOWS



Figures 8 and 9 show the escalated negative, positive and net cash flows of Stage 1. Because the real fuel cost escalation for both cash flows is based on coal there is little difference from the unescalated cash flows but for completeness they should be included.

TABLE 8

NET PRESENT VALUES ($000)

INTEREST RATE PERCENT	STAGE 1 UNESCALATED	STAGE 1 ESCALATED	TOTAL UNESCALATED	TOTAL ESCALATED
3.0	1,058,231	1,142,194	1,931,995	2,026,967
7.625	587,587	617,111	1,013,233	1,039,700
11.1	471,301	487,578	776,755	789,674
14.5	412,646	422,663	650,951	658,368
16.25	391,370	399,380	604,176	609,981
100.0	101,510	101,537	107,573	107,596
500.0	13,535	13,535	13,546	13,456

Table 8 and figure 10 show the net present values of Stage 1 and the total project. At the authorized rate of 7.625 percent the net present value of Stage 1 is about $600,000,000 and that of the total project is about $1,000,000,000. As the interest rate increased the NPV decreases but even at 500 percent does not become negative. At 600 percent it still is not negative and above that the NPV is not computable. This is not unexpected given the nature of the cash flows which are mostly positive with a relatively minor component.

Figure 8

ESCALATED GREGORY COUNTY STAGE 1 CASH FLOWS ($000)

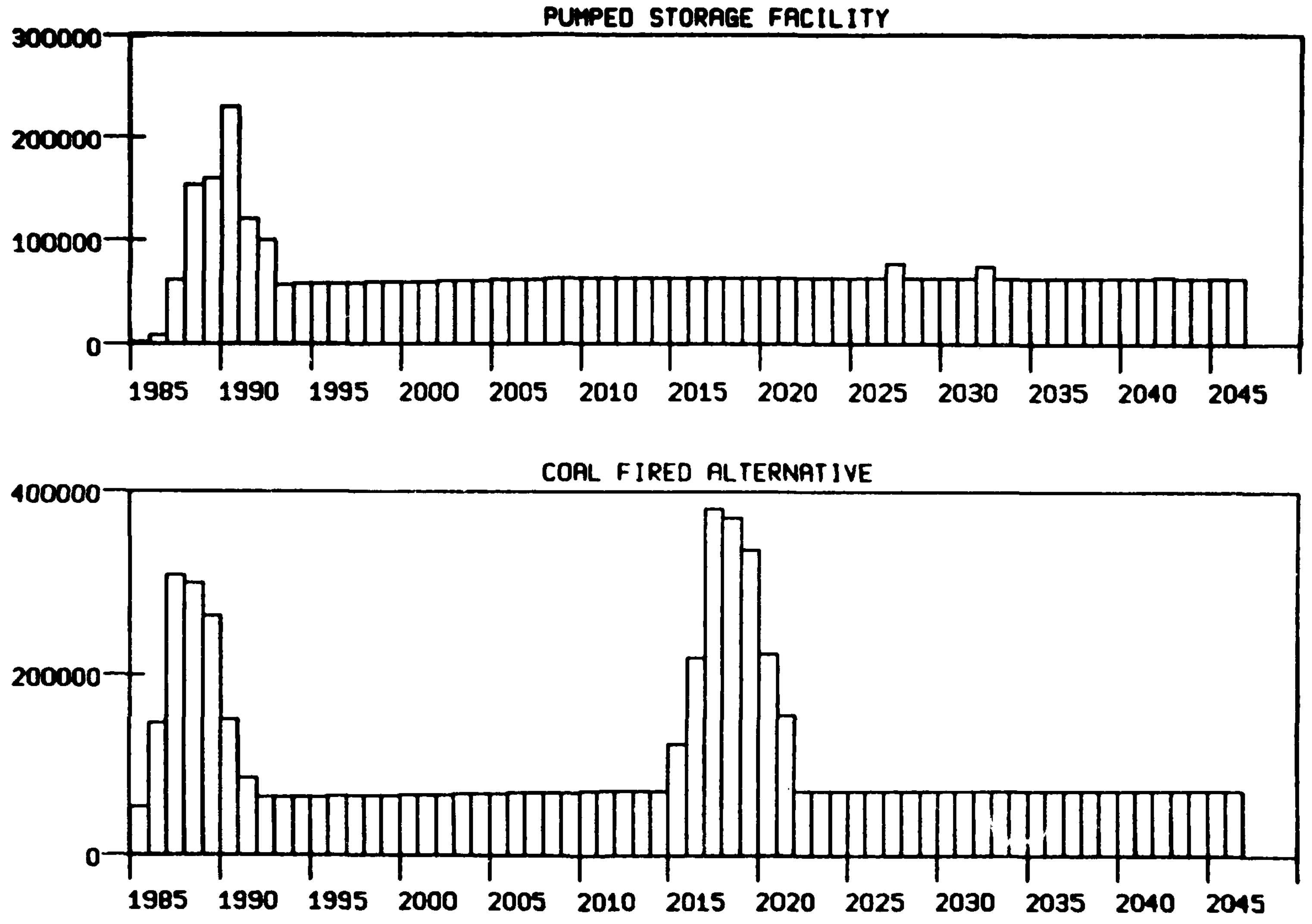


FIGURE 9
ESCALATED GREGORY COUNTY STAGE 1 NET CASH FLOWS

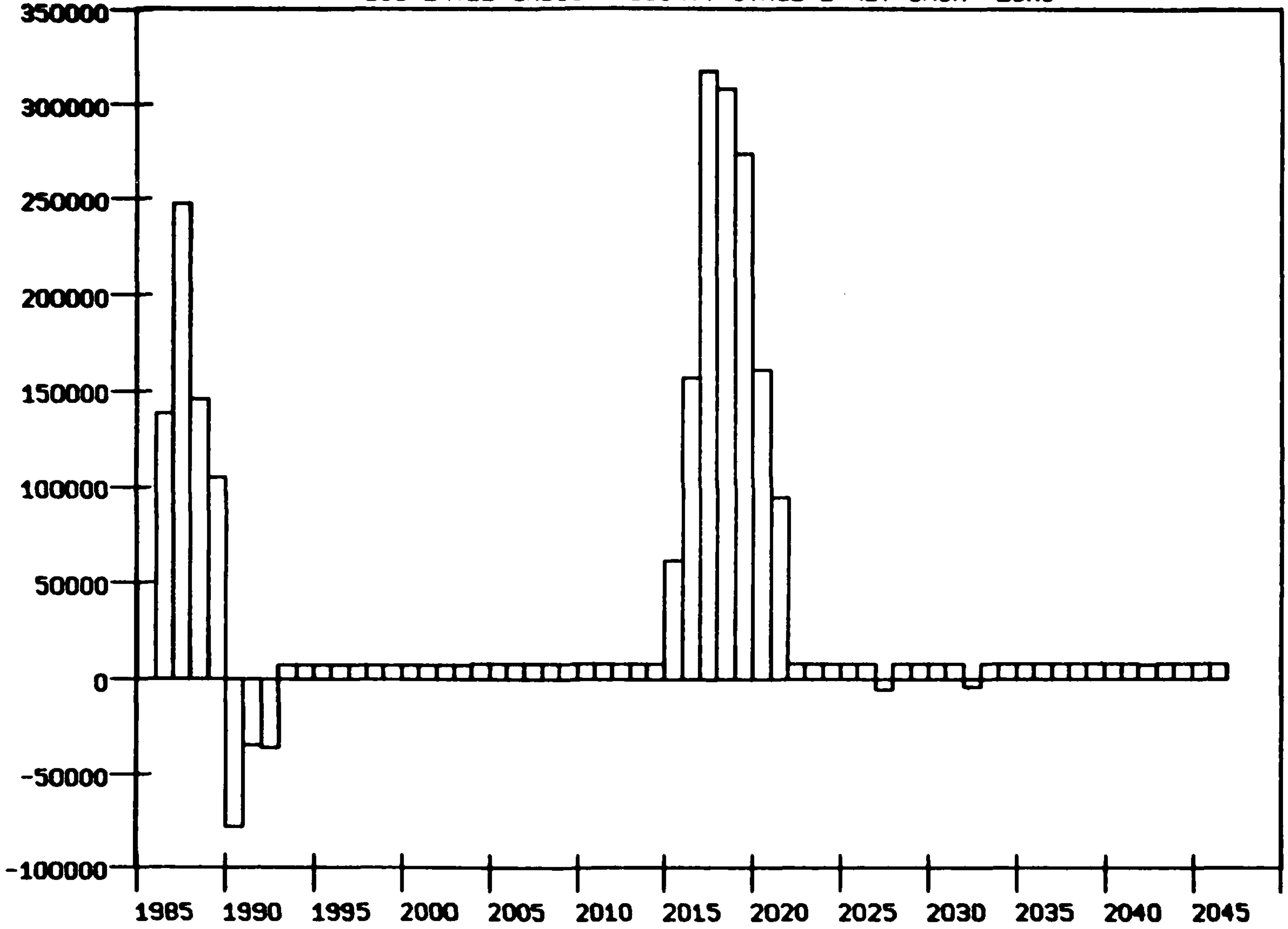
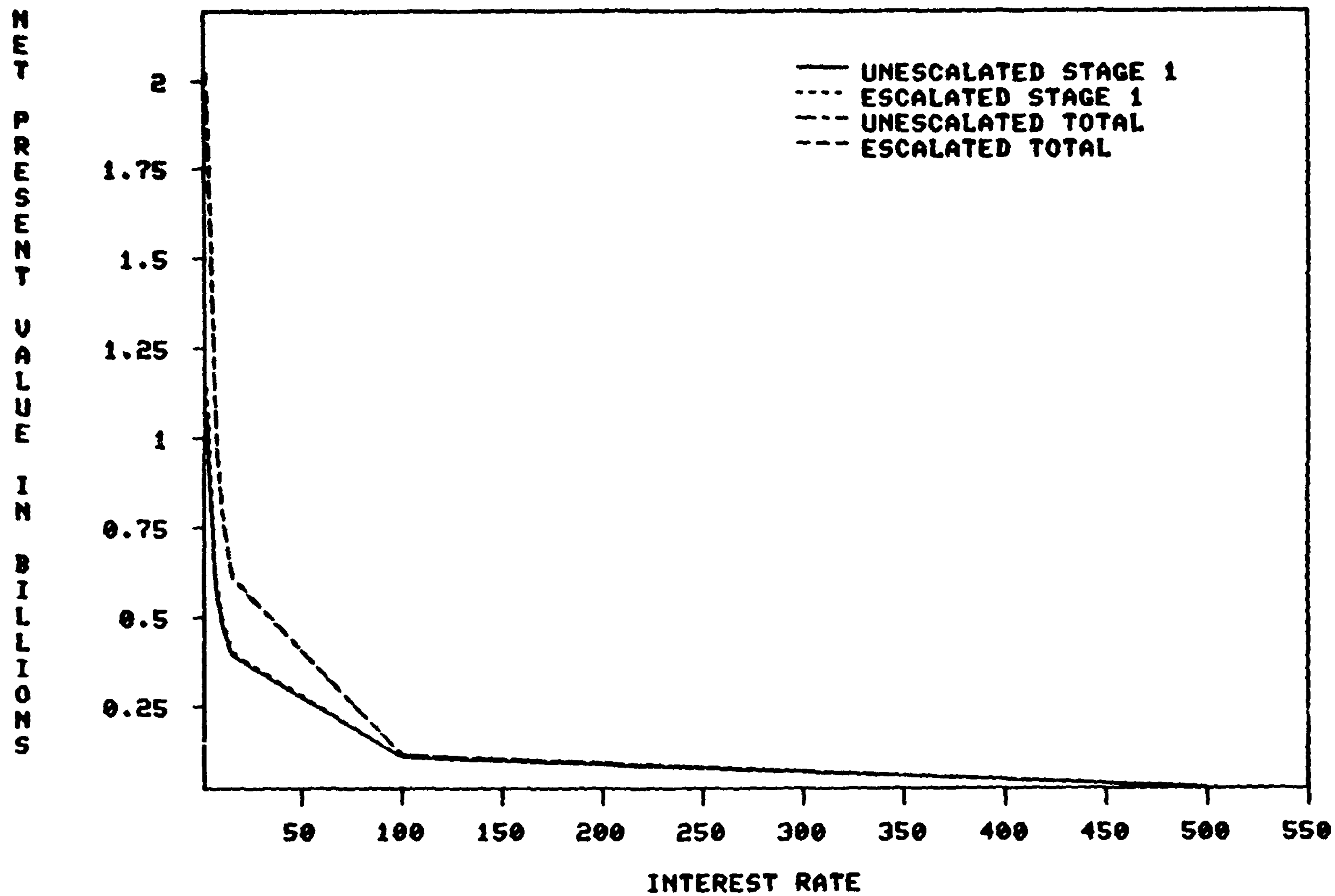


Figure 10

STAGE 1 AND TOTAL FACILITY NET PRESENT VALUES



Because the NPV is positive at all interest rates a valid IRR cannot be calculated if benefits are based on the coal fired alternative.

Gregory County demonstrates the two major differences between the economic analysis of hydropower and other water resource projects. First, the benefits as well as the costs change with the interest rate. Because of this increase a hydropower project may not be infeasible at any higher interest rate using the B-C ratio and annual net benefits criteria. And second, an IRR is not calculable for some hydropower projects because a valid IRR and NPV analysis requires a stream of net cash flows unaffected by interest rates.

US Army Corps
of Engineers
Engineer Institute for
Water Resources

AD P002642

Effects of the Discount Rate on the Civil Works Program

Policy Study 82-0900

July 1982

EFFECTS OF THE DISCOUNT RATE
ON THE CIVIL WORKS PROGRAM

Prepared by:

MARK W. MUGLER

U.S. Army Engineer Institute for Water Resources
Water Resources Support Center
Kingman Building
Fort Belvoir, Virginia 22060

Policy Study 82-0900

July 1982

PREFACE

This report was prepared as part of the Fiscal Year 1982 Policy Studies Program by the U.S. Army Engineer Institute for Water Resources (IWR), for the Office of Policy, Office of the Chief of Engineers (OCE), U.S. Department of the Army.

The report was written by Mr. Mark W. Mugler under the supervision of Mr. Kyle E Schilling, Chief, Policy Studies Division, IWR in coordination with the project technical monitor, Mr. Robert Kaighn, Chief, Research and Interagency Coordination Division, Office of Policy, OCE. Additional review, comment and guidance were provided by the following:

Mr. R. D. Teeters, DAEN-CWR
Mr. Bory Steinberg, DAEN-CWB
Mr. Donald Duncan, DAEN-CWR-P
Mr. Steven Hudak, DAEN-CWB-E
Mr. Richard Smith, DAEN-CWB-D
Mr. Bob Daniel, DAEN-CWP-S
Mr. John Bogue, DAEN-CWP
Mr. Weldon Opp, NPAEN-PL c/o DAEN-CWR
Mr. John McCann, BERH
Mr. Richard Hartman, BERH
Mr. Hilton Keen, BERH
Mr. Harold Kinback, BERH
Mr. Jesse McDonald, LMVPD-E
Mr. Robert Rook, NPWEN-PL
Mr. Robert Harrison, WRSC-IWR
Dr. Lloyd G. Antle, WRSC-IWR
Dr. Howard Olson, WRSC-IWR
Dr. James Tang, WRSC-IWR

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. SUMMARY AND CONCLUSIONS

Interest is the price that must be paid to obtain resources now rather than in the future. Interest is positive because resources available in the present are usually more highly valued than equivalent resources available in the future. The values of equivalent goods and services available at two points in time can be compared using compound interest.

The interest rate used in the economic analysis of water resource investments is called the "discount rate." The higher the discount rate, the more discounted (reduced) is the value of future goods and services compared to equivalent present goods and services. Conversely, the cost of amortizing a water resource investment is increased.

The official discount rate now in use was adopted in 1968 by administrative rule of the Water Resources Council and was reaffirmed by Congress in the Water Resources Development Act of 1974. Under the rule and the act, the official discount rate is based on the yields of U.S. Government bonds, subject to a limitation on annual changes of one-fourth of 1 percent. Since the official discount rate is based on the nominal cost of Federal funds, it includes an inflation "premium." However, the economic analysis of public investments involves measuring anticipated benefits costs in "real" terms, i.e., independent of inflation and deflation. From the standpoint of economic theory, the discount rate should also be a real value. The greater the inflation rate and the more sustained the inflation, the more inflated is the official discount rate and the greater is its inconsistency with other economic analysis principles. As a result, average annual benefits are reduced and average annual costs increased disproportionately.

There is widespread agreement that the existing formula for the discount rate is incorrect, and that the discount rate should be a real rate. However, the proper magnitude of the discount rate to be used for public investment analysis is difficult to estimate because real interest rates in the economy are masked by differing levels of risk, the effects of taxation, inflationary expectations and other factors. Consequently, the proper public sector discount rate remains a matter of intense debate. Proponents of the "opportunity cost of capital" theory hold that public investments should provide a real return at least as high as that provided by the private investments displaced by public taxation and borrowing. On the other hand, proponents of the "social interest rate" theory argue for a low discount rate suitable for promoting public investment, assuring long-term economic growth and meeting the needs of future generations. Compared to the use of a low "social" discount rate of, say, 3 percent, the use of high "opportunity cost" rate of, say, 8 to 10 percent signifies that society is less willing to sacrifice today's consumption opportunities to invest for the benefit of future generations.

It is clear that the magnitude of the discount rate affects the for lation of water resource projects. Most Federal water projects are capital-intensive (i.e., a high proportion of costs are incurred early), have a long design life and generate benefits which grow over time. A comparatively high discount rate affects those characteristics in the

following ways. First, future benefits would be more deeply discounted and early costs would increase in importance. Consequently, project features would be more likely to involve substitution of deferred or recurrent costs for first costs, as in the substitution of beach nourishment operations for structural shore protection, or the substitution of dredging for levee construction to maintain flood channel capacity. Second, long design life would offer little advantage in generating benefits. Consequently, a reduction in design life which enables savings in capital costs would be encouraged. Third, any project purpose which fails to provide immediate benefits would be more difficult to justify. For instance, projects with long-term economic development effects, however substantial, would fare poorly compared to projects of which the benefits are based on immediate deliveries, immediate savings or immediate protection. Finally, projects for which benefits are based on market or demand values (such as navigation and flood control) would fare poorly compared to projects for which benefits are based on capital-intensive alternative costs (such as hydropower or water supply).

The magnitude of the discount rate also affects the number and size of recommended water projects and the potential cumulative level of investment in water resources. The effects of a comparatively high discount rate would be as follows. First, the comparative decline in benefits and increase in costs would mean that last-added increments to scale and or extent of some projects would no longer be justified. For instance, in a flood protection plan certain reaches would be excluded or the level of protection reduced. In a waterway improvement plan certain reaches would be excluded or the navigable capacity reduced. Second, for some projects the benefits would no longer exceed the costs, even after reformulation, and the project could not be recommended. For instance, it is estimated that application of a 10 percent discount rate to the current backlog of pending Civil Works projects could reduce the number which are economically justified by as much as half, even after reformulation. Third, by promoting projects with relatively high operation, maintenance and replacement costs compared to first costs, a high discount rate would eventually result in the allocation of a proportionately smaller share of the water resources budget to new investments.

In 1974, Congress did not foresee the high rates of inflation and nominal interest which have prevailed since that time. Although limited in its rate of change, the discount rate has followed the nominal cost of Federal borrowing upward from 4 5/8 percent in fiscal year 1969 to 7 5/8 percent in fiscal year 1982. If the high financial interest rates such as those which have prevailed recently were to continue, the official discount rate would continue to rise for years and would remain relatively high indefinitely.

The 1974 act attempted to limit variation in the discount rate by limiting annual changes to one-fourth of 1 percent and by "grandfathering" the discount rates applicable to most projects authorized prior to 1969. These small and frequent variations in the discount rate create added cost because annual reanalysis is required, and create uncertainty in programming and budgeting because discount rate increases can adversely affect the feasibility of recommended projects. In addition, for most projects, decades can pass between completion of a survey report and completion of advanced engineering and design. During those decades the official discount rate can change

substantially. Consequently, the cumulative changes in the discount rate, along with changes in physical and economic conditions and in other policies, contribute to the need for extensive replanning of "old" projects. At the same time, projects with "grandfathered" interest rates become controversial as their economic performance under the current rate is cast in doubt.

In the final analysis, the magnitude of the discount rate has a significant effect upon the types of water projects to be built and the potential cumulative level of investment. However, any analysis of existing and alternative methods to compute the discount rate must address not only its magnitude, but also the uncertainties and inconsistencies which can result from dependence on nominal interest rates.

II. INTRODUCTION TO THE DISCOUNT RATE

The Functions of Interest

According to economic theory, interest performs two closely related functions. First, interest is the price that must be paid by borrowers to induce savings; interest is positive because of "time preference," the preference of individuals and institutions for control of resources now rather than in the future. Second, interest is the measure of the minimum return on investment necessary to justify borrowing or diverting resources from alternative investments; it measures the "opportunity cost of capital," the cost of foregone investment or consumption opportunities.

The perfect market economy is an economy which is riskless, tax-neutral and inflation-free, and in which information is costless. In the perfect market economy, there would be one economy-wide interest rate at which time preference and the opportunity cost of capital (i.e., supply of savings and the demand for savings) would be equalized. Each potential investment, whether public or private, could be evaluated to ascertain whether its return exceeded the economy-wide interest rate. However, the economy of the United States is not perfect, and there are many observed rates, each rate reflecting different risk, tax liability, quality of information and inflationary expectations. Although each household, corporation or institution has a different interest rate, these different rates are, in theory, equivalent to the underlying interest rate after adjustment for inflation, risk, taxes, etc.

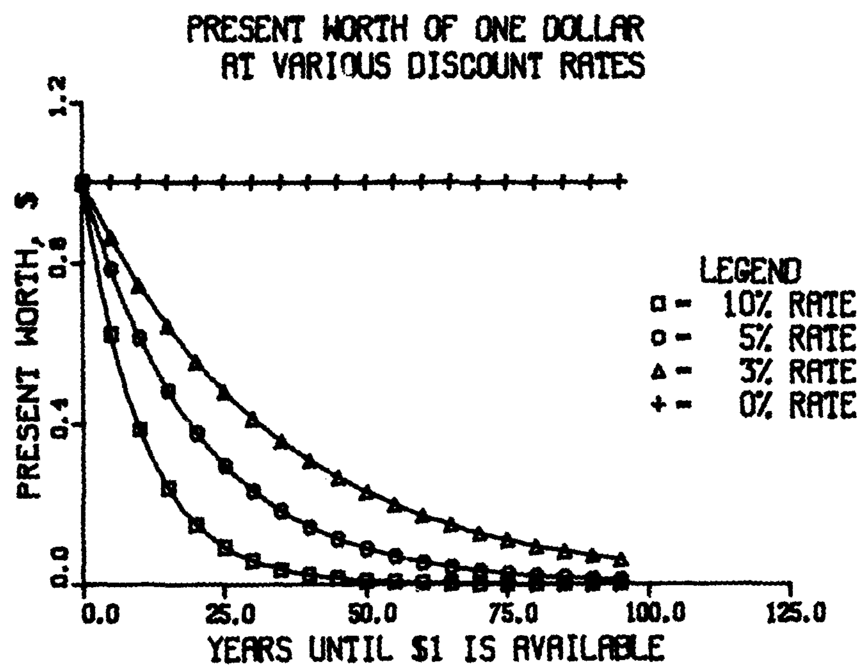
Benefit-Cost Analysis and Discounting

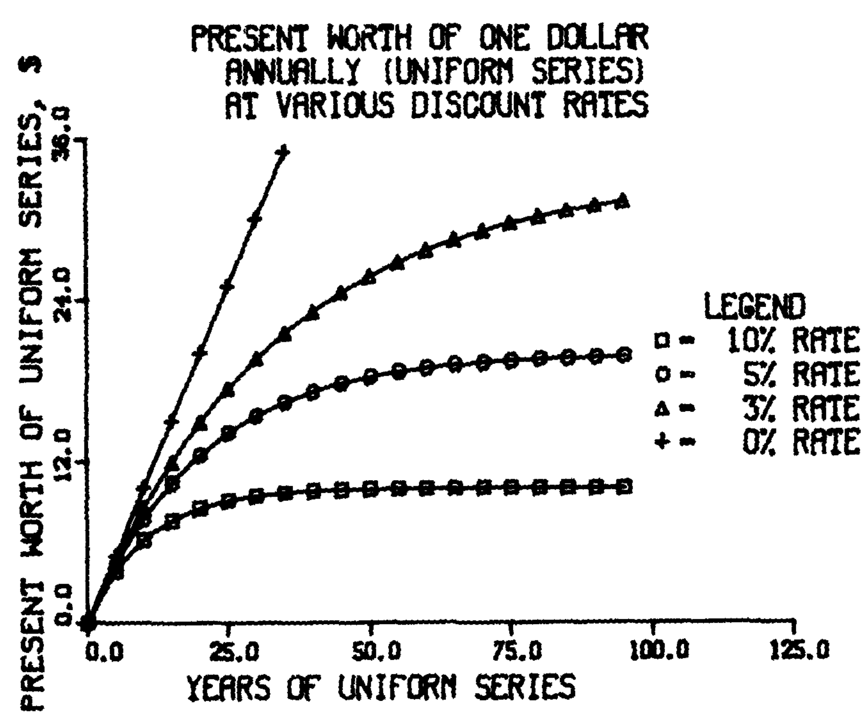
For Federal water development agencies, "benefit-cost analysis" is the method of economic analysis used for the evaluation of proposed investments. Federal agencies have used benefit-cost analysis since the landmark 1936 Flood Control Act, in which Congress stated that the Chief of Engineers may recommend Federal participation in flood control projects "if the benefits to whomsoever they may accrue are in excess of the estimated costs...."

The interest rate used in benefit-cost analysis is called the "discount rate." The values of future goods and services, whether received as benefits or expended as costs, are reduced, or "discounted," using the discount rate to find their equivalent present values, or "present worth." The discount rate is used to provide a common-time basis for comparing present and future benefits and costs and to develop plans which maximize net benefits through time. The discount rate should equal the underlying real interest rate, expressing simultaneously time preference and the opportunity cost of capital.

The further in the future a good or service is to be available, or the higher the discount rate, the more heavily the future good or service is discounted and the less its present worth. As shown in Figure I, $1.00 available in 25 years is valued at about $.30 using a 5 percent discount rate, but at only about $.09 using a 10 percent discount rate. As shown in Figure II, an income stream of $1.00 per year approaches a present worth of $20.00 at a 5 percent discount rate, but approaches only $10.00 in present worth at a 10 percent discount rate.

FIGURES I AND II





Benefit-cost analysis is a form of "economic analysis," and consequently deals with "real" values, i.e., values independent of changes in general price levels and the value of money due to inflation or deflation. ("Financial analysis," on the other hand, treats "nominal" or observed values which reflect price levels). To provide a proper basis for comparing values in benefit-cost analysis, both the discount rate and the values of anticipated benefits and costs should be measured in real terms, independent of inflation.

Under current procedures for computing benefits and costs, all present and future costs and benefits are measured in real terms. The discount rate is then used to convert construction costs and future benefits and costs to their present worth as of the "base year" at the beginning of project operation. Using the discount rate, costs incurred during construction are "brought forward" to the base year by charging compound interest from the date the costs are incurred, and subsequent costs and benefits are discounted to present worth as of the base year. In effect, the early costs are increased and subsequent costs and benefits are reduced. Using the same discount rate, these values may then be converted to annual equivalents using interest and amortization (I&A) tables. (The values have the same proportions whether compared in terms of present worth or annual equivalents). The ratio between benefits and costs is the benefit-cost (B/C) ratio. A project with a B/C ratio greater than 1.0 (i.e., of which the annual benefits exceed the annual costs) is generally considered economically feasible. The project design which provides the greatest excess of annual benefits above annual costs is called the "National Economic Development (NED) Plan," and may be recommended unless certain other project specific considerations such as human safety or environmental protection justify a deviation.

Concepts of the Public Sector Discount Rate

According to economic theory, the discount rate for the economic analysis of public investments should equal the underlying economy-wide interest rate, the "real rate of interest." One of the challenges of public investment economics is to estimate the real rate of interest. To derive this theoretical interest rate, most economists favor one of two theories: the "opportunity cost of capital" theory and the "social interest rate" theory.

The "opportunity cost of capital" theory holds that public investments must provide a real (economic) return at least as high as the private investments displaced by public taxation and borrowing. The advantage of using this concept is that it disciplines public investment by requiring competitive returns. The disadvantage of this concept is that the returns to be expected from the business and nonbusiness investments actually foregone cannot be determined. Available data pertains to average rates of return. The average opportunity cost of capital is usually recognized as being quite high (say, 10 percent) because private investors attempt to obtain a high rate of return after allowing for risk and taxes consequently, the upper limit of the real return on investments actually foregone is about 10 percent.

Proponents of the "social interest rate" theory argue for a low interest rate to promote investment, assure long-term economic growth and meet the needs of future generations. They recognize that public investments may

generate significant indirect or secondary effects which are irrelevant to private investors, and that since future generations cannot participate in today's decisions, society may exhibit a time preference different from that of individuals. One way to estimate the "social interest rate" is to adjust the yields on low-risk corporate or Federal bonds for inflation and taxes. Over the years this rate has usually been in the 1 to 3 percent range.

There is a third widely espoused approach to the public sector discount rate, the "cost of Federal borrowing" approach. This is a budgetary approach to public investment with little basis in economic theory. Proponents of this approach argue that the return from public investments should at least offset the cost of governmental borrowing to finance the investment. The discount rate would vary with the interest rate on Federal debt instruments having the same time to maturity as the payout period of the investment, say, 50 to 100 years. The major disadvantage of this approach is that although Federal borrowing is risk-free, the cost of Federal funds is a nominal rate, highly variable and dependent upon monetary policy and inflationary expectations. Because it is a nominal rate with no basis in theory, it has little support among economists as the basis for the discount rate. In addition, the Federal Government has not issued many long-term securities for a number of years, and the cost of Federal borrowing must be extrapolated from the yield rates on shorter-term securities, now approximately 13 percent.

Because the assumptions, data and methods used in these three concepts are quite different, they yield quite different estimates of the appropriate discount rate. The "social interest rate" estimate is approximately 3 percent; the "opportunity cost of capital" estimate is up to 10 percent; the cost of Federal borrowing has ranged from 2 to 15 percent. Furthermore, due to the complexity of the national economy, estimates using the same general concept differ among themselves. Finally, these estimates, like conditions in the overall economy, change over time. Because there is no agreement on the proper discount rate, it has remained a subject of controversy for decades.

III. EFFECTS OF THE DISCOUNT RATE ON THE CIVIL WORKS PROGRAM

In the final analysis, the magnitude of the discount rate has a significant effect upon the types of water projects to be built and the potential cumulative level of investment. However, any analysis of existing and alternative methods to compute the discount rate must address not only its magnitude, but also the uncertainties and inconsistencies which can result from dependence on nominal interest rates.

The Official Discount Rate

The official discount rate now in use was adopted in 1968 by administrative rule of the Water Resources Council and was reaffirmed by Congress in the Water Resources Development Act of 1974. The rule and the act: (a) set the discount rate at 4 5/8 percent for fiscal year 1969; (b) based the discount rate for subsequent fiscal years on the effective yield (annual dividend divided by market value) of U.S. Government bonds with 15 years or more left to maturity; (c) limited annual changes in the discount rate to one-fourth of 1 percent; and (d) retained a 3 1/4 percent discount rate for all authorized projects for which satisfactory assurances of local cooperation had been received by 31 December 1969 (i.e., "grandfathered" the project discount rates).

The current method for computing the discount rate has three important features:

(1) It is based on the nominal cost of Federal funds in financial markets rather than a measure of real interest. Under current procedures for benefit-cost analysis, the benefits and costs prior to discounting are measured in real terms, but the official discount rate, which is a nominal rate, includes an inflation premium and is inconsistent with other economic analysis principles. Because of its dependence on nominal rates, the existing method of computing the discount rate is considered by many to be lacking in theoretical justification and inappropriate for evaluating water resources investments.

(2) It has risen continually. In 1974, Congress did not foresee the dramatic effect of linking the discount rate to the nominal cost of Federal funds. In the 1960's the nominal cost was 3-4 percent and approximated the real cost of funds. The range which prevails today is 12-14 percent, and includes a large inflation premium. Consequently, the official rate has risen over the years, from 4 5/8 percent in fiscal year 1969 to 7 5/8 percent in fiscal year 1982. At some time in the future the official rate will reach the nominal cost of borrowing, and would surpass the cost of funds should nominal rates decline. Clearly the present method will produce a relatively high discount rate for years to come.

(3) It varies on an annual basis. While the discount rate should vary from time to time to reflect underlying conditions in the economy, many consider changes which are both frequent and small to be unnecessary and administratively burdensome.

Effects of Discount Rate Magnitude on Project Formulation

Application of a relatively high discount rate in evaluating public projects implies that society is relatively unwilling to sacrifice present-day consumption opportunities to gain future consumption opportunities, and also that the return on foregone investment opportunities is quite high. By contrast, use of a relatively low discount rate implies that society is relatively willing to forego immediate consumption and alternative investments for the benefit of future generations. The higher the discount rate, the shorter the time horizon for project planning and the greater and more immediate the desired return on public investment.

Effects on Benefits and Costs

For any project, the pattern, or "stream" of costs over time differs from the stream of benefits. Consequently, the effect of the discount rate on the present worth and annual equivalent of costs is different from its effect in the present worth and annual equivalent of benefits. The different effects have implications in turn for the selection of project scale, features and purposes.

Table I shows the effect of the discount rate on the values of a project's benefits and costs. The annual values of first costs (i.e., investment costs) are equal to the interest and amortization charges computed using the discount rate. Consequently, changes in the annual values of first costs are approximately proportional to changes in the discount rate. In contrast, the values of benefits or costs which do not occur until some time in the future (such as one-time replacement costs) or which increase over time (such as the long-term benefits of waterway improvement projects) are more severely discounted with an increase in the discount rate, and will decrease. (At a very high discount rate, the values of future benefits or costs are so heavily discounted that a further increase in the rate has little further effect.) In the case of benefits or costs which are constant over time, the effects of discounting and of annalizing present worth would exactly offset each other. Consequently, discounting is irrelevant and is not used for constant annual benefits and costs.

A relatively high discount rate not only penalizes plans with high first costs or with benefits which grow over time, but also removes the economic advantage of a long design life. However, high first cost, benefits which grow over time and long design life are precisely the characteristics of the traditional Civil Works projects. Consequently, the higher the discount rate used in project evaluation, the less likely is a traditional project to be recommended.

TABLE I

ECONOMICS OF A TYPICAL PLAN [1] AT THREE DISCOUNT RATES

	Value at 0% D.R.	Value at 5% D.R.	Value at 10% D.R.
Construction Cost and Interest During Construction, $M	500	553	611
Annual Costs, $M			
Interest and Amortization	10.0	30.3	61.6
Operation and Maintenance	10.0	10.0	10.0
Total	20.0	40.3	71.6
Total Discounted Benefits, $M	2500	784	384
Annual Equivalent Benefits, $M	50.0	42.9	38.7
Net Annual Benefits, $M	30.0	2.6	(32.9)
Benefit-Cost Ratio	2.50	1.07	.54

[1] 5-year construction period; 50-year project life; initial benefits $30M; undiscounted benefits in year 50 $70M; construction cost $500M; annual O&M costs $10M.

For example, the proposed Big Wood River and Tributaries project was evaluated in 1976 at a 6 1/8 percent discount rate and in 1981 at a 7 5/8 percent discount rate. As shown in Table II, benefits and undiscounted costs rose about 57 percent overall. However, because of the change in the discount rate the annual equivalent (interest and amortization) of the first cost rose 95 percent. As a result, net benefits rose only 42 percent and the benefit-cost ratio declined from 3.07 to 2.53.

Effects on Project Features

The higher the discount rate used for project evaluation, the greater is the inducement for the project designer to delay costs (thereby minimizing their present worth) and to capture benefits quickly (thereby maximizing their present worth). As the discount rate rises, recurrent costs, which are affected by the discount rate little or not at all, will be substituted for capital costs. For example, with a 5 percent discount rate, a construction cost savings of $100 could justify incurring an additional $5 per year in operation and maintenance (O&M) costs, whereas at 10 percent, the $100 construction cost savings could justify an additional $10 per year of O&M costs.

At the Cape May Inlet, New Jersey, two groins are the preferred method to achieve an improvement in beach erosion protection if the discount rate is 7 percent or below. However, as shown in Table III, at a discount rate above 7 percent, the amortized cost of the groins exceeds the recurrent cost of nourishing the beaches with sand impounded by the inlet jetties, and beach nourishment is preferred. This is true even though the real, undiscounted life cycle cost of the groins is much lower.

Because at a high discount rate recurrent costs are more likely to be substituted for capital costs, "management plans" with low first costs and few structural features would be selected more frequently. In addition, because the values of nonmonetary environmental attributes are not discounted while monetary values are discounted, a high discount rate would make it more worthwhile to preserve and enhance nonmonetary attributes.

Effects on Project Scale or Extent

Often a high discount rate will necessitate a reduction in the scale or extent of a project. A high discount rate reduces the present worth of the "last-added" future benefits while increasing the present worth of the last-added increments to capital cost. Consequently, with an increase in the discount rate, project scale, such as the level of flood protection or the dimensions of a navigation channel, may need to be reduced until the last-added benefits equal the last-added costs. In other cases, the geographic area affected by a project must be reduced. For instance, development of marginal reaches of a waterway may no longer be justified, or marginal reaches affected by floodflows of a certain river can no longer be protected.

TABLE III

COMPARISON OF ANNUAL COSTS OF
ALTERNATIVE PLAN FEATURES
PROVIDING EQUIVALENT BEACH EROSION
PROTECTION, CAPE MAY, NEW JERSEY[1]

Alternative Feature	Cost Component	Undiscounted Life-Cycle (50 year) Cost	Annual Cost at Various Discount Rates: 3 Percent	5 Percent	7 Percent	10 Percent
Two groins	Capital	1,410,000	54,800	77,200	102,000	142,200
	Recurrent	2,600,000	52,000	52,000	52,000	52,000
	Total	4,010,000	106,800	129,200	154,000	194,200
Beach nourishment (50,000 c.y.)	Recurrent	7,750,000	155,000	155,000	155,000	155,000
	Total	7,750,000	155,000	155,000	155,000	155,000

Source: Board of Engineers for Rivers and Harbors, correspondence pertaining to "Cape May Inlet to Lower Township, New Jersey, Phase I GDM." Figures based on "Plan E." Simplifying assumptions have been used.

TABLE II

PROJECT ECONOMICS, 1976 and 1981, BIG WOOD RIVER AND TRIBUTARIES IN THE VICINITY OF GOODING AND SHOSHONE, IDAHO

	1976 Prices, 6 1/8% Discount Rate	1981 Prices, 7 5/8% Discount Rate	Percent Change [1]
Construction cost (first cost)	2,450,000	3,840,000	+57
Annual cost:			
I&A	150,500	293,000	+95
OM&R	7,000	9,300	+33 [2]
Total	157,500	302,300	+92
Annual benefits:			
Flood reduction - present development	433,610	688,170	+59[3]
Flood reduction - future development	40,340	60,790	+51[3]
Reduced cost of floodproofing	8,900	16,490	+85
Total	482,850	765,450	+59
Net benefits	325,350	463,150	+42
Benefit-cost ratio	3.07	2.53	--

Source: Walla Walla District, U.S. Army Corps of Engineers.

[1] Price levels used in most computations of costs and benefits increased more rapidly than general price levels.

[2] The labor component of OM&R costs did not rise as quickly as construction costs and other materials costs. As a result, overall OM&R price inflation was relatively low.

[3] Projected beginning of operation was delayed 5 years. As a result, real value of "present development" increased slightly and the period of growth in future damages was reduced by 5 years. Overall, change in flood reduction benefits was 56 percent.

A plant to pump floodwaters impounded behind a levee near Yazoo was authorized at a 2 1/2 percent discount rate. Using that discount rate, the optimum plan would pump 25,000 cubic feet per second (cfs) of water and provide net annual benefits of $18.7 million per year. However, as shown in Table IV, at a discount rate of 7 5/8 percent and the same price levels, the optimum plan is smaller (17,500 cfs) and the net benefits are only $5.1 million. The smaller plan provides less flood protection behind the levee.

Effects on Project Purposes

Most Civil Works projects are multipurpose projects with a variety of benefits. Projects and purposes vary in their capital-intensivity, the pattern of their benefits over time and their design life; consequently, the discount rate can be expected to have varying effects.

With regard to flood damage reduction, very few plans for which the benefits are principally "future development" benefits which growing over time are justified at a high discount rate. Flood protection projects with substantial immediate benefits, on the other hand, are less adversely affected. As the B/C ratio of a flood protection plan declines toward 1.0 with a rise in the discount rate, the level of protection or geographic extent of flood control projects may be reduced. Flood warning systems, flood plain regulations and other management activities may be substituted for structural solutions. Recurrent costs, as in the case of dredging to maintain flood capacity, may be substituted for capital costs, as in the case of levee construction.

Navigation is a project purpose which is clearly affected by the discount rate. In particular, for large waterway development projects it takes decades for traffic to grow; consequently, at a high discount rate the navigation benefits which lie far in the future would be too severely discounted to offset the construction costs. Navigation projects which are based to a large extent on immediate benefits are not as severely affected. Projects which require little initial investment but have substantial annual costs, such as clearing and snagging or emergency dredging, would not be as severely affected as more capital-intensive projects.

The effects of the discount rate on a shore protection project depends on the nature of the project. Capital-intensive projects and projects which rely on slowly developing recreation benefits are adversely affected by a high discount rate, while projects involving beach nourishment (a recurrent cost) or which generate immediate benefits are relatively unaffected.

For certain purposes the benefits are measured by the cost of alternative investments to provide the same outputs. For example, the benefits of hydropower, water quality and municipal and industrial water supply are usually calculated based on the costs of alternative sources of energy, water pollution control and water supply, respectively. The same interest rate is applied to a proposed project. If the alternative is as capital-intensive as project costs allocable to that purpose, the economic feasibility of that purpose may be unchanged. Consequently, purposes with benefits based on alternative costs are less severely affected by a high discount rate.

TABLE IV

COMPARISON OF PLANS AT TWO DISCOUNT RATES,
YAZOO AREA PUMP STUDY

Plan Capacity (cfs)	Plan First Cost ($000)	2 1/2% Discount Rate				7 5/8% Discount Rate			
		Annual Cost ($000)	Annual Benefits ($000)	Net Benefits ($000)	Benefit-Cost Ratio	Annual Cost ($000)	Annual Benefits ($000)	Net Benefits ($000)	Benefit-Cost Ratio
10,000	86,800	3,851	14,305	10,454	3.7	8,684	12,666	3,982	1.5
15,000	126,200	5,801	19,902	14,101	3.4	12,828	17,984	4,766	1.4
17,500	147,400	6,787	22,825	16,038	3.4	14,994	20,143	5,149[1]	1.3
20,000	175,400	7,949	25,347	17,398	3.2	17,715	22,368	4,653	1.3
25,000	212,900	9,639	28,310	18,671[1]	2.9	21,493	24,989	3,496	1.2
30,000	250,600	11,142	29,412	18,270	2.6	25,095	25,957	862	1.0

Source: Lower Mississippi Valley Division, U.S. Army Corps of Engineers.

[1] Optimum Plans

"Later, the Water Resources Council appointed a Task Force to study new principles and standards, and that report was completed in the Fall of 1971. On the basis of that report the Council published proposed new principles and standards in the Federal Register for public comment in December of 1971, and held hearings on them throughout the country in Spring of 1972. No further publication or public participation, or consultation with other entities occurred until, suddenly in September of this year the Council announced new principles and standards which differ markedly from those which were proposed in 1971.

"A new formula was prescribed by the Council for determining the discount rate which is to be applied to Federal and federally assisted water resources projects. The rate, which is to be established initially at 6 7/8% and which may vary by 1/2 of one per centum per year, is to be based on the average yield of all interest bearing marketable securities of the United States, both long and short term, outstanding at the end of the fiscal year preceding such computation. This formula differs markedly from the previous formula adopted by the Water Resources Council in 1968.

"The committee is greatly concerned with the effect this new discount formula would have on the justification of water resources projects that are essential to meet the needs of future generations. The higher the discount rate, the less future benefits are worth when discounted to present-day values. Thus, the formula encourages* capital-intensive projects which provide for immediate or early near-future benefit returns, and lessens the opportunity to build projects which are designed to satisfy the needs of future generations. While this approach may be appropriate for private business, it is not a satisfactory basis for public investment which should concern itself with planning for resources projects designed to meet the resource needs of future generations. Other objectives such as assistance to chronically depressed areas such as Appalachia and the Upper Great Lakes Region, and the preservation of a viable natural environment may also bear significantly on the discount rate determination. Use of the higher discount rate would foreclose opportunities which would otherwise be available when future water resources needs of the Nation become even more critical than at present. Indicative of the effect of the proposed discount rate is a rough calculation relating to 377 active authorized projects of the Corps of Engineers. Only 176 of these, or about 47%, would remain justified at the proposed discount rate of 6 7/8%....."

Source: U.S. Congress, Committee on Public Works, Report on the Water Resources Development Act of 1973 and the River Basin Monetary Authorization Act of 1973, House Report 93-541, 93d Congress, 1st Session, October 3, 1973.

*So in original

Because they are capital-intensive and have a long design life, multipurpose reservoirs are sensitive to the discount rate. The effect of the discount rate on any particular reservoir also depends on the pattern of benefits over time of the project purposes. With a high discount rate, the present worth of benefits attributable to water supply deliveries, flood protection or recreation use which begin far in the future will be reduced. On the other hand, hydroelectric power, flood protection of existing developments, water quality enhancement and water supply activities with immediate benefits or payback are not as adversely affected. The major overall effect of the discount rate on multipurpose reservoirs is to change the cost allocations and the scale. At a high discount rate, last-added costs will be allocated to purposes with benefits which are based on alternative costs or which are immediate; purposes with far-off benefits will be reduced in scale and extent. In addition, some reservoirs will be reduced in scale as capital-intensive features are replaced by alternatives such as water conservation or nonstructural plans. Some reservoirs will no longer be justified.

Effects of Discount Rate Magnitude On Potential Cumulative Level of Investment

For a number of reasons, a high discount rate reduces the potential cumulative level of investment. First, a high discount rate implies that the level of investment per project will be reduced compared to investment under a low rate, both because the scale of recommended projects is reduced and because recurrent costs are substituted for capital costs.

Second, since most Civil Works projects are capital-intensive and involve benefits which grow over time, the number of recommended projects is also likely to be reduced at a high discount rate. For instance, the congressional committee reporting on the 1974 Water Resources Development Act (reference 15) estimated that, had the interest rates applicable to projects authorized prior to 1969 not been "grandfathered" by Congress, 176 (47 percent) of 377 active Corps projects would no longer have been economically justified at a 6 7/8 percent discount rate. Hanke (reference 5) reported that, without reformulation, only 6 of 17 Bureau of Reclamation projects investigated would be economical at an 8 1/2 percent rate, and only 3 would be economical at a 10 1/2 percent rate. In 1981, a number of Corps of Engineers divisions estimated the benefits and costs for 13 authorized Corps of Engineers projects[1] at 3 different discount rates. At the authorized rate (3 1/4 percent in all but case) all 13 are economically justified. Without reformulation, only 9 are justified at a 7 5/8 percent discount rate, and only 3 are justified at a 10 percent rate.

---

[1]Bradley Lake, Bonneville Power Units, Strube Lake, Randleman Lake, Big Pine Lake, Onaga Lake, Burlington Dam, Little Dell Lake, Maalaea Small Boat Harbor, Cedar River Harbor, Eldred and Spankey Levee and Drainage District, Kake Harbor and Red River Basin Chloride Control.

For this report 224 authorized projects awaiting construction appropriations and 89 recommended projects awaiting authorization were surveyed. Results are displayed in Table V. Highlights of Table V are as follows:

- Among the 88 projects economically justified at a grandfathered rate, only 48 are justified at the current rate, and only 21 are relatively certain to remain justified at a rate of 10 percent.

- Among 213 projects without a grandfathered rate, 19 are no longer justified at current rates, and only 106 are relatively certain to remain justified at a 10 percent rate.

In effect, the recent rise of the discount rate has already had a dramatic effect on the number of pending projects. Should the discount rate be increased to 10 percent, as much as 59 percent of the existing backlog would be uneconomical without reformulation. It is estimated that, even with reformulation, nearly one-half of all pending projects could no longer be recommended at a 10 percent discount rate.

Since the discount rate affects both the size and the number of pending projects, it places an upper limit on the potential cumulative level of investment. If the discount rate were high enough it, rather than budgetary constraints, would limit the annual investment budget. Even if the annual water resources budget is constrained by the availability of funds rather than the discount rate (as in the case today) the discount rate still affects the level of investment over time because it affects the mix of capital costs versus recurrent costs which must be financed out of the budget. In all cases, the higher is the discount rate, the lower is the potential level of investment.

Effects of Discount Rate Variability

Although economic conditions are not static, small and frequent variations in the discount rate create added uncertainty in programming and budgeting and added administrative cost because of the need for annual updating. In addition, for most projects, decades can pass between completion of a survey report and completion of advanced engineering and design. During those decades the official discount rate can change substantially. Consequently, the cumulative changes in the discount rate, along with changes in physical and economic conditions and in other policies, contribute to the need for extensive replanning of "old" projects. At the same time, projects with "grandfathered" interest rates become controversial as their economic performance under the current rate is cast in doubt.

TABLE V

SENSITIVITY OF BENEFIT-COST RATIOS OF PENDING
CIVIL WORKS PROJECTS TO THE DISCOUNT RATE

Type of Project Surveyed	Total Number Surveyed	BCR>1/0@ Applicable Rate	BCR> 1.0 @ 7 5/8%	BCR> 1.4 @ 7 5/8%[1]
By Status of Project:				
- authorized, grandfathered, awaiting construction appropriations	100	88 (88%)	48 (48%)	21 (21%)
- authorized, not grandfathered, awaiting construction appropriations	124	105 (85%)[2]	105 (85%)[2]	51 (41%)
- Recommended, awaiting authorization	89	89 (100%)[2]	89 (100%)[2]	55 (62%)
By Project Type and Major Benefit[3]:				
- Local Flood Control	114	100 (88%)	83 (73%)	33 (29%)
- Flood Control Reservoir	26	23 (88%)	18 (69%)	8 (31%)
- Water Supply Reservoir[3]	19	16 (84%)	11 (58%)[3]	0 (00%)[1,3]
- Hydropower Reservoir[3]	21	21 (100%)	19 (90%)[3]	13(62%)[1,3]
- Beach Protection	19	17 (89%)	17 (89%)	13 (68%)
- Deep Draft Channels and Harbors	33	33 (100%)	32 (97%)	26 (79%)
- Shallow Draft Channels	15	13 (87%)	12 (80%)	9 (60%)
- Small Boat Harbors	18	16 (89%)	15 (83%)	10 (56%)
- Other	48	43 (90%)	35 (73%)	15 (31%)
For All Projects:	313	282 (90%)	242 (77%)	127 (41%)

Source: Programs Division, Office of the Chief of Engineers.

[1]BCR >1.4 @ 7 5/8 percent is used as a proxy to indicate potential lack of justification at a discount rate of 10 percent. Some purposes, particularly those with benefits based on alternative cost, will not be as adversely affected as indicated.

[2]Applicable rate is 7 5/8 percent.

[3]Most projects are multipurpose and provide more than one type of benefit. Only the major benefit is listed. For instance, among the five "water supply" reservoirs which are not justified at a 7 5/8 percent discount rate, water supply benefits comprise from 30 percent to 77 percent of benefits. Although in each case water supply benefits are based on alternative costs, the presence of other purposes and benefits explains much of the decline in the BCR's.

REFERENCES

Baumol, William J., "On the Discount Rate In Public Projects," Public Expenditures and Policy Analysis, Robert H. Haveman and Julian Margolis, eds., Markham, Chicago.

Bousquet, Kenneth J., "Remarks Before the Southeast Basins Interagency Committee," Atlanta, April 17, 1968.

Cohn, Edward, "The 3 1/4 Discount Rate," unpublished.

Graham, James C., "The Relationship of Inflation, Price Levels and the Discount Rate in Benefit-Cost Analysis," U.S. Army Corps of Engineers, Board of Engineers for Rivers and Harbors, Planning Associates, 1980.

Hanke, Steve H. and James Bradford Anwyle, "On the Discount Rate Controversy," Public Policy, Spring 1980.

Hanke, S. H., P. H. Carver and P. Buggy, "Project Evaluation During Inflation," Water Resources Research, August 1975.

Haveman, Robert H., "The Opportunity Cost of Displaced Private Spending and the Social Discount Rate," Water Resources Research, Vol. 5, October 1969.

Jones, Ralph C., "The Appropriate Rate of Discount for Public Projects," research paper, Seminar in Natural Resource Planning, Allen V. Kneese, Instructor, January 1969.

MacAuley, Patrick H., "Trends in the Construction Industry, 1965-80," Construction Review, U.S. Department of Commerce, Bureau of Industrial Economics, May-June 1981.

McCann, John, "The Role of the Interest Rate in Water Resources Planning," unpublished.

National Water Commission, Water Policies for the Future, Final Report to the President and to the Congress of the United States, U.S. Government Printing Office, June 1973.

Samuelson, Paul A., Economics, McGraw-Hill, Inc. 1970.

Seagraves, J. A., "More on the Social Rate of Discount," The Quarterly Journal of Economics, Vol. 84, No. 2, August 1970.

Tang, James, and Lloyd G. Antle, "A Review of Discount Rate Models for Evaluating Water Resource Projects," unpublished, 1982.

U.S. Congress, Committee on Public Works, Report on the Water Resources Development Act of 1973 and the River Basin Monetary Authorization Act of 1973, House Report 93-541, 93d Congress, 1st Session, October 3, 1973.

U.S. Congress, Joint Economic Committee, Subcommittee on Economy in Government, Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis: Hearings, U.S. Government Printing Office, 1968.

U.S. Congress, Joint Economic Committee, Subcommittee on Economy in Government, Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis: A Report, U.S. Government Printing Office, 1968.

U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States, 1980.

U.S. Department of Commerce, Bureau of Industrial Economics. "Construction Cost Indices" Construction Review, July-August 1981.

U.S. Water Resources Council, Planning and Cost Sharing Policy Options for Water and Related Land Programs, Part 4: Options for the Discount (Interest) Rate, U.S. Government Printing Office, 1975

U.S. Water Resources Council, Reference Handbook for Use with the Principles and Standards and Procedures for Water Resources Planning (Level C), Fiscal Year 1981, October 1980.

Western Agricultural Economic Research Council, Committee on the Economics of Water Resources Development, The Discount Rate in Public Investment Evaluation, Report No. 17, Water Resources and Economic Development of the West, Conference Proceedings, Denver, December 17-18, 1968.

APPENDIX A:
EXCERPT FROM THE COMMITTEE REPORT ON THE 1974 WATER RESOURCES DEVELOPMENT ACT

"SECTION 80

"This section enacts into law the interest rate formula used in the formulation and evaluation of water resource projects as established by the Water Resources Council in 1968. It also enacts into law the so called "Grandfather" provision adopted by the Water Resources Council to determine the applicability of the 1968 formula to previously authorized projects.

"The use of a discount rate in benefit-cost analysis had its origin in the National policy expressed in the 1936 Flood Control Act that Federal participation in the provision of flood protection is justified if the benefits exceed the cost. However, prior to 1953 there was no standard procedure in use to compare projects of the various Federal Agencies. Though not consistent for all agencies, a rate of 3% was generally in use for the period 1936-1952. Between 1952 and 1959, the discount rate was based on the formula prescribed in BOB circular A-47, issued on 31 December 1952, which was the average rate of interest, or coupon rate, paid by the Treasury on marketable securities which had terms to maturity of 15 years or more. This coupon rate varied from 2.5% in 1953 to 3.25% in 1968.

"In 1965 the Congress enacted into law the Water Resources Planning Act. The purpose of that act was to encourage the conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis by the Federal Government, States, localities, and private enterprise with the cooperation of all affected Federal agencies, States, local governments, and others concerned.

"To achieve this goal of comprehensive and coordinated planning, the Water Resources Council was established, composed of the heads of the various Federal agencies involved in water resources. One of the specific duties assigned to the Council by the Congress was the establishment, after consultation with other interested entities, and with the approval of the President, principles, standards, and procedures for Federal participants in the formulation and evaluation of Federal water and related land resources. One part of these principles and standards is the discount rate formula to be used.

"On December 24, 1968 the Water Resources Council adopted a new formula for computing the interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs in the preparation of comprehensive regional or river basin plans and the formulation and evaluation of Federal water and related land resources projects. This formula is based on the yield rate of marketable securities which at the time of computation have 15 or more years remaining to maturity. The current rate (July 1973) on this basis is established at 5 5/8 percent.

Summary

Application of a relatively high discount rate adversely affects the economic justification of capital-intensive projects with long design lives or with benefits which grow over time. The adverse effects are less severe for projects with benefits based on alternative costs, with a high proportion of recurrent to capital costs, or which are limited in scale, extent or design life.

A high discount rate reduces the potential cumulative level of investment. Not only is the size and capital-intensivity of each project reduced, but also fewer projects can be recommended. For instance, if a 10 percent rate were applied to all pending projects, over half would not be justified without reformulation and it is estimated that nearly half would not be justified even with reformulation. Finally, over time the use of a high discount rate would increase the proportion of the budget allocated to recurrent costs rather than investment costs.

The official discount rate now in use is based on nominal interest rates, and changes on an annual basis. During periods of sustained inflation, the official discount rate rises to include an inflation premium, becoming increasingly inconsistent with other enconomic analysis principles. In addition, the variability of the official rate adds to uncertainty in plan formulation and in programming and budgeting.

Any analysis of existing and alternative methods to compute the discount must address not only its magnitude and also the uncertainties and inconsistencies which can result from dependence on nominal interest rates.

PROCEEDINGS

A Meeting on the Evaluation of External Effects of Water Projects

21 September 1981, Washington, D. C.

Sponsored by the

Institute for Water Resources
Army Corps of Engineers

PROCEEDINGS FROM A MEETING ON EVALUATION OF EXERTNAL EFFECTS
Held on 21 September 1981
Washington, D.C.

Summary and Recommendations

Table of Contents

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

It has been recognized that many water resource projects have generated significant unintended and uncompensated for benefits and costs due to the interdependence of project elements and external economic activities and that these external effects, especial the beneficial external effects important to the local communities, the affected regions or to the nation as a whole, are sometimes difficult to trace and measure. To explore what can be done to remedy the situation, the Institute of Water Resources called a meeting of 14 consultants and Corps personnel on 21 September 1981 in Washington during which 9 papers were presented and major issues in evaluating external effects were discussed. A brief summary of the papers, major issues discussed, and recommendations are as follows.

SUMMARY OF PAPERS PRESENTED (in order of presentation)

1. Evaluation of External Effects of Water Resources Projects (James Tang). This paper was mailed to the participants in advance providing the background of the meeting and outlining the major issues for discussion. The paper observes that economic literature is biased toward external diseconomies and the issue of external economies has received little attention. WRC's final rules on evaluation of external effects are reproduced in the paper for ready reference.

2. External Effects and NED Evaluation (Frank H. Bollman). This paper, presented by Dr. Bollman who took a major role in preparing the WRC's final rules, reinforces the notion of national economic development (NED) benefits as the conceptual basis for evaluating external economies and diseconomies. Only an improvement in production efficiency (as indicated by a shift of the production curve showing an increase in output by same amounts of input or the same amounts of output can be produced by lesser amounts of input) may be

counted as external economies. The shift in the production possibility or schedule or in the utility function of an individual may not be confused with a movement along the same schedule which represents a relative change in factor combination due to price change and seldom represents an improvement in efficiency or in consumer satisfaction. Several computation examples are given.

3. <u>Decisions, Externalities, and the With and Without Conditions</u> (Brad Fowler). Observing that evaluation of external effects is difficult for various reasons such as the ex post nature of external effects, unable to subject to experimentation, and magnitude of the problem and others, the author suggests that it is important to search for and identify all significant impacts with and without the projects and to sift through the various definitions to determine their appropriate externality, NED, transfer or regional character.

4. <u>External Effects And Regional Impacts</u> (Robert L. Leonard). The author provides an excellent literature review and traces how the concepts of external effects were treated in public policy statements from the 1958 Green Book to the 1980 Principles and Standards. External effects are discussed in economics literature under two different contexts: under the general equilibrium theory, external effects refer to the impacts emenating from direct interdependence among producers or consumers, while under the context of a developing economy or the theory of industrialization, both direct and indirect (those transmitted through the price system) impacts are recognized as important. The author believes that the current definition of external effects is consistent with the equilibrium theory's basic assumption and attempts to broaden

this concept to include pecuniary externalities may not be consistent with the competative character of the U. S. economy.

5. A Case Study of Potential External Benefits from the McClellan-Kerr Navigation System, Preliminary Observations (Samuel Ben Zvi). Following a discussion of the concept of technological external benefits, the author described his observations of some of the projects effects which may be considered external effects under certain hypostheses to be further investigated.

6. External Effects of Water Resources Projects Construction Activities (Art Harnisch). Major external effects both beneficial and adverse should be identified and quantified where possible. The range of external effects should cover not only NED but also RED, OSE and EQ. The adverse or external diseconomies when quantified will provide a measure of mitigation funds which may be necessary during the short term construction period. Mitigation of short-term, external adverse effects could lead to long-term external benefits. Appendix A includes a paper showing how external effects may be managed by mutual agreement and monitoring between a hydro project owner and an effected community.

7. Institutional Approach to Reduce Flood Damages Via Negotiated Investment Strategy (NIS) (Art Harnisch). A negotiated investment strategy as described in this paper may be a valuable tool for managing external diseconomies.

8. Comments on Gallispolis Lock and Dam Replacement, Ohio River, Phase I Study (Thomas Odle). In commenting on the study, the author presents a theoretical approach to congestion fees and corrects some misunderstanding about the concept and implications of congestion fee charges.

9. Lock Congestion and Pricing Policy (Ungsoo Kim). The economic concept of lock congestion and its social costs and the basic considerations for pricing congestion fees are examined in the paper.

ANALYSIS OF ISSUES

The major issues in evaluation of external economies and diseconomies that were discussed at the meeting or dealt with in the papers presented are summarized in the following paragraphs.

1. Conceptual framework. As noted in the papers by Tang, Bollman and Leonard, external economies in the context of the equilibrium theory would exclude regional economic development benefits and other social effects in the computation of NED benefits of water projects. While it is possible to clarify the concept and improve the procedure and enable the planner to capture the external economies within the equilibrium framework as in the case of the unforseen recreation benefits in the McClellan-Kerr Navigation System and in the several examples cited in the paper by Bollman, the issue remains to be what weight should be assigned to the RED and OSE accounts. This is a political decision. All the planner can and should do, as suggested in Fowler's paper, is to search for all significant effects, sift them through the various definitions according to their NED, RED, OSE and EQ characteristics and present the full story to the decision-makers.

2. Range of External Effects. As pointed out in Harnisch's paper, the range of external effects extends beyond the NED account to reach the RED, OSE and EQ accounts. To identify external effects under each of these accounts can probably enhance a planning study. Such a display was utilized in the formulation of a negotiated investment strategy in the case study reported by Harnisch.

3. Mechanism for managing external effects. What should be the appropriate mechanism for handling external effects is an issue that was not discussed at the meeting. The negotiated investment strategy and the monitoring system as described by Harnisch et al may have considerable merits.

4. Congestion Fees. Congestion has increasingly become a problem at many Corps locks and dams. The two papers presented here attempt to explain some of the basic concepts and issues in congestion fees. Tentative conclusions are: congestion fees are transfers and do not represent a gain in efficiency and, charging a congestion fee is a temporary and not a permanent solution to the problem of optimal efficiency.

RECOMMENDATIONS

1. Papers presented at this meeting should provide sufficient information and insight into the complex subject of external effects evaluation. Little can be gained by further research into the theory and procedures for evaluating external effects.

2. It is desirable to take another look at the impacts of the McClellan-Kerr Navigation System from the viewpoint of external effects along the line suggested in the paper by Ben Zvi.

AD P002644

Inflation & Measurement of the Opportunity
Cost of Private Capital

Jim Crews
Transportation Research & Analysis Center
Orlando, Florida

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF TABLES (Continued)

TABLE OF TABLES (Continued)

TABLE OF TABLES (Continued)

EXECUTIVE SUMMARY

This paper discusses the determination of an appropriate discount rate for use in evaluating new planning and construction starts for water resources projects. The importance of the discount rate stems from its use in the discounting process, whereby a common time-frame is provided for the comparison of the costs and benefits of a potential water resources project. In general, the lower the discount rate applied to the evaluation of a project's benefits and costs, the higher the Benefit-Cost Ratio (BCR) of the project. Therefore, the lower the discount rate used in the evaluation process, the larger the number of projects that can be economically justified.

Because of this relationship between the discount rate and the economic evaluation of public investments, including water resources projects, the determination of an appropriate discount rate has been the focus of numerous studies, academic articles, government directives and Congressional hearings during the past several decades. Due to the complexities, both theoretical and empirical, involved in the determination of the discount rate, no concensus has been reached on exactly how such a rate should be determined. However, the extended debate on the discount rate has resulted in the resolution of some issues, with the effect that the appropriate discount rate can be characterized by the following three properties:

(1) The appropriate discount rate should be determined by one of the following three concepts:

(i) The Opportunity Cost of Capital - This concept specifies the discount rate as that rate of return which could be earned if the funds invested by the government had been left in the private sector, i.e., the before-tax rate of return on private investments.

(ii) The Collective P . ate Rate of Time Preference - This concept specifies the discount rate as the rate at which society evaluates the trade-off between present and future consumption, i.e., the after-tax rate of return on private savings.

(iii) The Weighted Average Approach - This concept embodies the earlier two concepts, recognizing that public investments at least potentially displace both private investment and private consumption. The discount rate is then a weighted average of the two rates denoted above, with the weights determined by the relative proportions of investment and consumption displaced by public investments.

(2) The discount rate should generally not reflect the effects of inflation, since benefits and costs are normally computed in inflation-free (constant) dollars.

(3) There is no rate of interest observed in the marketplace that corresponds to the discount rate. (It should be noted that under current inflationary conditions, this would follow directly from (2) above. However, even in the absence of inflation there are numerous reasons this would still be correct, most notably the existence of taxes and imperfect capital markets.)

The approach taken in this paper for the estimation of the discount rate is based on the opportunity cost of capital concept. The prime reason for using this approach is not a belief in its correctness, but the recent Council of Economic Advisers initiative and past Office of Management and Budget (OMB) directives asserting that this is the correct approach for determining the discount rate and that this approach, when properly applied, yields a discount rate of 10%. The results of this investigation indicate that this approach does not yield a 10% discount rate, that past empirical estimates yielding 10% are generally both empirically and logically incorrect estimates of the discount rate, and that as an empirical issue the three approaches yield estimates over a much narrower range than has been previously suggested, when all sectors of the U.S. private domestic economy and the effects of inflation are correctly accounted for in the estimating procedures.

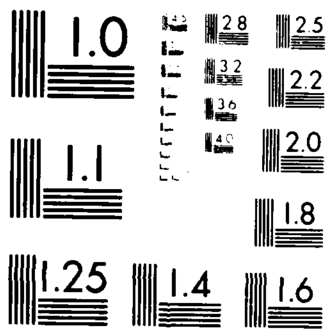
Past estimates of the discount rate as the opportunity cost of capital have generally contained two flaws. First, estimates of income have not been derived from an overall system of national accounts to insure that income is correctly allocated between sectors of the economy and to eliminate the possibility of double counting income. Secondly, estimates of the real rate of return are usually derived by subtracting some inflation rate from some computed nominal rate of return based on the Fisher equation relating real and observed rates of interest. This adjustment does not yield a real rate of return that is relevant to investment decisions.

The methods used in this paper to estimate the discount rate are based on procedures developed in a series of articles by Laurits R. Christensen and Dale W. Jorgenson. This procedure is based on the development of income, wealth, production, expenditure and accumulation accounts of the national economy, which serve as controls on private income, investment and revaluation of wealth. Information from the National Income and Product Accounts (NIPA), studies that have been incorporated into NIPA, and some imputations are used to determine before-tax income (or property compensation) for the four types of legal organizations: corporate, non-corporate, households and institutions. Implicit price deflators from NIPA are used to create a real series on capital stocks and depreciation. These in turn are transformed to a current dollar series on capital stocks and depreciation.

Development of these accounts and the income, capital stock and depreciation series were accomplished for the years 1948-1979. For each year and each legal form of organization it is possible to compute rates of return as the ratio of current income less current depreciation to the current value of the capital stock. This represents the relevant rate of return for

AD-A136 867 PROCEEDINGS: ECONOMIC AND SOCIAL ANALYSIS WORKSHOP HELD AT ST LOUIS MISSO..(U) ARMY ENGINEER INST FOR WATER RESOURCES FORT BELVOIR VA L G ANTLE OCT 83 IWR-83-P-40 4/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

investment decisions in an inflation free economy in the sense that it computes the ratio of income to capital stock, with the capital stock valued at current prices. The results of this analysis are shown in Table E-1. For the U.S. private domestic economy, the average rate of return over this period is 8%.

This result is also confirmed by other studies, which use different data sources and methods, but are oriented towards the same issue. One example is a study by G.M. von Furstenberg, B.G. Malkiel and H.S. Watson (1980) entitled, "The Distribution of Investment Between Industries: A Microeconomic Application of the 'q' Ratio" (6, 1980). The focus of this study is not the determination of the real rate of return, but rates of return are computed in this study as a by-product of the determination of industry q-values. (An industry q-value is the ratio of the market valuation of its assets to the current replacement of those assets.) They state, "In spite of their crudeness, the impression that real after-tax rates of return on total industry assets generally average less than 6 percent in the United States is overwhelming. It is also broadly compatible with previous estimates . . . for the nonfinancial corporate sector over the period 1952-1976" (6, 1980). The previous estimate they refer to is a study by G.M. von Furstenberg (10, 1977) which implies a comparable rate of return of 4.7% on the replacement cost of total assets. Although not presented here, the after-tax rate of return in the corporate sector implied in this analysis would be about 6-7%. Use of replacement costs rather than investment deflators would lower this figure somewhat.

The conclusion of this paper is that based on the opportunity cost of capital approach, the appropriate discount rate is significantly less than the 10% advocated by OMB and CEA. In fact, over the 1948-79 period of analysis the yearly rate of return in this study is as high as 10% in only two years. The results of the present analysis suggest that a discount rate in the neighborhood of 8% is most likely at the upper end of the spectrum of the candidates for the discount rate. (In general, the possible errors in the data base and the computations presented in this analysis tend towards an upward bias of the estimated rate of return.) For example, publicly owned but privately used capital is excluded from the capital stock, although income derived from publicly owned capital assets is at least partially captured by the income computations. Inclusion of these publicly owned but privately used capital assests would lower the estimated rate of return, although the overall magnitude of this impact is unclear.

TABLE E-1

BEFORE TAX REAL RATES-OF-RETURN BY SECTOR
(Percentage)

Year	Private Domestic Economy	Corporate	Non-Corporate	House-holds	Institutions
1948	8.05	14.91	10.03	3.28	-1.65
1949	7.28	13.40	9.91	2.26	-1.38
1950	6.87	15.55	5.35	3.54	-1.92
1951	7.37	15.42	7.57	3.04	-1.36
1952	6.83	13.70	6.36	3.74	-1.31
1953	7.06	13.38	7.98	3.35	-1.22
1954	7.10	12.68	6.79	4.88	-1.29
1955	8.15	15.41	8.74	4.19	-1.09
1956	7.94	13.88	10.31	3.76	-1.17
1957	6.90	12.88	8.36	2.99	-1.37
1958	6.17	11.58	4.99	4.27	-1.23
1959	7.39	13.84	7.77	3.86	-1.14
1960	7.42	13.14	6.55	5.25	- .93
1961	7.32	13.26	6.14	5.16	- .89
1962	8.22	14.85	7.70	5.30	- .77
1963	8.63	15.58	8.34	5.38	- .87
1964	9.33	16.49	9.33	6.28	- .59
1965	10.13	17.94	8.92	7.01	- .44
1966	10.33	17.86	9.17	7.27	- .15
1967	9.89	16.03	10.44	6.56	- .10
1968	9.01	15.97	7.00	6.28	.02
1969	9.18	14.58	7.66	7.41	.30
1970	7.82	12.24	7.02	6.17	- .35
1971	8.13	12.70	7.25	6.39	- .19
1972	8.58	13.19	6.72	7.39	- .04
1973	8.44	13.08	5.60	7.71	.34
1974	7.67	10.52	8.24	6.27	.08
1975	7.96	10.59	11.10	5.26	- .34
1976	7.48	11.71	5.97	5.87	- .14
1977	8.69	12.66	7.54	7.30	.37
1978	8.28	12.23	7.30	6.81	.30
1979	7.75	11.30	6.95	6.52	.21
Average	8.04	13.83	7.78	5.34	- .64

ECONOMIC AND SOCIAL ANALYSIS FOR MILITARY PROGRAMS:

THE FORT BUCHANAN, PUERTO RICO REALIGNMENT STUDY

Alan V. Galdis*

Introduction

In the spring of 1976, the U.S. Army Forces Command (FORSCOM) requested that Mobile District's Planning Division conduct a study of Fort Buchanan, Puerto Rico. The purpose of the analysis was to identify and evaluate the potential impacts associated with various realignment actions being considered for the base. The objective of the study was to describe the anticipated effects of proposed actions in sufficient detail to allow FORSCOM to make an informed decision about the future of Fort Buchanan. The results of the study would also indicate if any of the proposed actions constituted a major federal activity requiring an environmental impact statement. This paper reports on the conduct of the study and suggests the potential for continuing cooperation between social scientists and military program managers.

Background

In the mid 1970's, the Department of Defense was investigating ways to reduce its costs while maintaining military capabilities. To meet these objectives, the agency decided to concentrate its effort on ways to reduce overhead and support expenses, and it considered base realignments as major components of these cost reduction measures. After preliminary studies by the Department of Army determined that Fort Buchanan was a viable candidate for further analysis, FORSCOM formulated four realignment plans and asked Mobile District to conduct a detailed investigation of the plans. The request was made in early spring of 1976; Planning

*Social Scientist, U.S. Army Engineer District, Mobile.

Division completed the study in August of that year. An environmental assessment, including the recommended alternative, was released by FORSCOM in January of 1977.

Setting

Fort Buchanan is located in the San Juan metropolitan area on the northern shore of Puerto Rico, which is the smallest of the Greater Antilles chain of islands (Cuba, Hispaniola, Jamaica, and Puerto Rico). The Antilles, Greater and Lesser, occupy an area of 1,500 east-west miles and 900 north-south miles. The islands are considered as a geographic unit with the Caribbean Sea its common link, but the area is heterogeneous in terms of ethnocultural aspects. The people are a mixture of Indian, African, and European lineages, and each island has a history of plantation-based colonization by foreign economic and political powers.

For the Fort Buchanan study, the entire island was identified as the area of study. This was done because it was suspected that some of the actions would have island-wide implications. In addition, much more data was available, especially for non-Census years, for the island as a whole than for any of its subdivisions.

As the study began, Puerto Rico was experiencing rapid population growth as well as a general decline in economic well-being, two characteristically interrelated phenomena. The number of inhabitants had increased from 2.6 million in 1967 to 3.1 million in 1975, an annual growth of 2.3 percent. This rate of increase was more than double the United States annual average of one percent for the same period. Both per capita and median household income had declined in 1974 and 1975 after annual rises from 1967-1973. The per capita figure fell by over 18 percent from 1973 to 1975, while household income lost 14 percent for the same period. Internal business volume fell in tandem with income, off 18.4 percent from 1973-1975. Unemployment was touching 20 percent

as the analysis began, and the island's consumer price index had risen nearly 16 percent in both 1974 and 1975. In sum, the island had experienced significant, sometimes severe recent declines in key socioeconomic indicators.

The Puerto Rico Planning Board's forecast for 1976 provided both positive and negative expectations. Price levels were expected to continue rising, but at a less jarring 6 to 9 percent rate. Sharp reductions, of about one-third, were expected in the total value of construction projects. Unemployment in excess of 21 percent was forecast for the year. On the positive side, manufacturing employment showed signs of increasing, and jobs lost as a result of permanent business closures were registering at lower levels than had been projected. Personal income was expected to increase by about nine percent, but the major portion of this growth was projected to be a 40 percent increase in transfer payments from the Federal government. Income from other sources was to experience only a mild increase. Overall, some sectors of the economy were forecast to realize mild advances during 1976, but conditions were expected to remain generally difficult, due in some measure to heavy reliance on the public sector as a principal stimulant of the economy.

In this uncertain and often gloomy socioeconomic setting, Fort Buchanan's 1,500 acres seemed almost pastoral. The base was a quiet area surrounded by busy highways, burgeoning subdivisions and extensive commercial areas. It offered large, open green areas with intervening limestone hills. Burglar bars, in evidence nearly everywhere in San Juan, were conspicously absent on the base. As a work place for its 1,100 employees, it approached being ideal. This calm appearance, however, belied the fact that thousands of people each week utilized various facilities on the base. These people and their activities became the focus of the study when the alternatives were analyzed.

Impacts of Alternatives

The alternative realignment strategies developed by FORSCOM included two plans which would close the installation completely (Alternatives I and II), one which would retain the base at a reduced level of operation

(Alternative III), and one which would maintain the status quo (Alternative IV). Either of the closure plans would have had the following quantifiable effects:

- Transferred about 150 military personnel off the island and eliminated over 600 civilian employee spaces

- Eliminated over $5 million in annual salaries and reduced local procurements by $4 million

- Required $17.6 million in one-time costs for actions at Fort Buchanan and other affected installations

- Saved $8.5 million in Department of Defense (DOD) annual recurring costs

- Moved about 200 families from base to community housing.

These numbers plus other military and civilian wage, housing, and family size data were inputted to an analytical tool known as the Economic Impact Forecast System (EIFS) which had been developed by the Corps of Engineers Construction Engineering Research Laboratory (CERL). This computerized model (which was run by hand for this study due to its lack of base data for Puerto Rico) was developed specifically to analyze the community effects of military base realignment actions. The model produced the following estimates of socioeconomic impacts on the island:

- Losses of $24 million in business volume

- Losses of $14 million in personal income

- Decrease of $2.5 million in housing expenditures

- Decrease of $9 million in non-housing expenditures

- Decrease of 620 local employees

- Decrease of $2 million in housing investment.

These figures represented a worst case scenario for Puerto Rico and also showed impacts for only one point in time. Even so, the aggregate effects on the island's total economy were minuscule. The negative impacts of

closure seemed to affect only the individual employees whose jobs were to be terminated.

There were other effects, however, which assumed greater proportions than the analysis had initially shown. These impacts began to be quantified in the later stages of the study, after closer inspection of the total closure plans. With no base, there would be no commissary, post exchange and other community support facilities. There would be no recreation fields and no green space. These words assumed a new meaning when it was discovered that there were nearly 70,000 residents of the San Juan area who, for one reason or another, could use the support facilities. These people and the military and eligible civilian employees spent almost $15 million in fiscal year 1975 at the commissary. The beverage store had sales of over $4 million, and the exhange system had net sales of $15.5 million on a volume of nearly two million customers. In addition, the Army welfare system made $1.4 million from exchange sales. Obviously, the impacts of closing the base were more pronounced than had been anticipated.

Further analysis revealed institutional impacts for the Navy at Roosevelt Roads Navy Station. This installation, located at the eastern end of the island, is a closed base requiring special identification and vehicle decals for admittance. A weekly influx of thousands of additional commissary and exchange customers would have created a security problem for the Navy, not to mention traffic problems. Also, there would have been increased congestion on the roads between San Juan and Roosevelt Roads.

There were institutional impacts for the Army to consider as well. Fort Buchanan was a visible link to the mainland, continuing evidence of the relationship between Puerto Rico and the Unites States. This meant a great deal to many on the island, not only business and government officials, but also retired military and civilian employees from both Puerto Rico and the mainland. The Army also had a very favorable public image in the San Juan area because it allowed local youth groups to use the recreation fields on base.

It became apparent that there was much more to this study than quantifying the loss of a few hundred jobs. There were impacts which were truly island-wide in their implications. Fort Buchanan played a significant role in the life of the San Juan area, a role far beyond the beauty of a few hundred acres and the livelihood of a few hundred employees.

Interpretation of Results

When the study entered its final stages, the effects of all components of the closure plans had been quantified. As noted earlier, the direct impacts on employment, income, and local procurement were detailed with a high degree of precision. The indirect effects associated with closing the community support facilities were analyzed in detail in order to produce quantified impacts which reflected reality as closely as possible. This was done by estimating both current community facilities' usage and future growth in the number of eligible residents. Impacts had also been noted for the Navy, and the institutional effects of all actions had been outlined. In sum, there had been a thorough analysis of the proposed plans, an analysis which went beyond the obvious effects and explored both the direct and indirect outcomes of each of the actions proposed by FORSCOM.

A close examination of the impacts showed that the major effects, the ones which would make a lasting impression on the community, were those which resulted from closing the commissary, exchange, and other support facilities. The study clearly showed that the eligible residents would have had considerable difficulty exercising their rights to utilize these facilities if they had to journey to Roosevelt Roads. The Navy, too, would have had difficulties dealing with the sudden influx of thousands of patrons at a secured installation. The Army would have been dealt a blow in its community relations program if it closed the recreation fields. Significant, also, would have been the loss of the base as a reminder of the positive relationship between the United States and Puerto Rico.

All of the initially non-quantified elements of the closure plans had potential negative effects. When the analysis provided an indication of the

severity of these effects, it became clear that Alternative III, the reduced operation plan, was the least disruptive because, while it did reduce the Federal government's annual recurring costs by $3 million, it retained the commissary, exchange, and other such facilities at full operational levels. It allowed retirees and other eligible residents the opportunity to utilize their rights without having to resort to elaborate entrance requirements, and it allowed the Army to keep the recreational fields open and available for local use.

In August of 1976, Planning Division submitted its final report to FORSCOM headquarters. After studying the report and considering the implications of all plans, the document was released as an environmental impact assessment in January, 1977. The preferred plan was Alternative III.

Lessons

By utilizing the expertise--and the insight--of social scientists, FORSCOM's program managers were able to obtain and assess valuable information which might otherwise have escaped them. The Planning Division study team took the plain statistics of reductions in employment and procurement as well as mission transfer data and produced a series of dollar impacts using the EIFS model's algorithms. This could have been done by anyone who took the time to study the model and its application procedures.

The other impacts were not so easily discerned. The raw data of community support facilities' usage was not subject to manipulation by a computer model, for there were delicate relationships existing between the community and the base which no mathematical formula could simulate. Social scientists, however, are educated and trained to recognize these interactions, and, although we cannot always model them successfully, we can recognize and describe them. In many cases we can approximate numerically what the relationships might look like and what their effects might be. For the subtlest of the correlations, though, mere discovery and description are all that is possible

Planning Division was able to define and in most instances quantify the effects of community support facilities' usage. In so doing, we were able to show what the impact of losing this usage would be for the community. We believe that our analysis provided a valuable service to FORSCOM by allowing them to assess the probable effects of this loss and act accordingly. They must have agreed, because in the following few years Planning Division was asked to study several other projects. In each of these other studies, the role of the social scientist was much in evidence--as a seeker of obscured facts and a definer of relationships which others fail to notice. In many cases, these facts and relationships make a difference; in a few, they make <u>the</u> difference.

ECONOMIC ANALYSIS
OF ALTERNATIVE MILITARY HOUSING
ACCOMMODATIONS

A TOPIC FOR PRESENTATION
AND DISCUSSION AT THE CORPS OF ENGINEERS
ECONOMIC AND SOCIAL ANALYSIS WORKSHOP
ST. LOUIS, MISSOURI
25-29 October 1982

William T. Hunt, Regional Economist
Michael S. Fenton, Computer Scientist
B. David Swenson, Supervisory Regional Economist
Michael G. Hopkins, Environment Capital Managers, Inc.

Pacific Ocean Division
Corps of Engineers
October 1982

Table Of Contents

ECONOMIC ANALYSIS OF ALTERNATIVE MILITARY HOUSING ACCOMMODATIONS

Introduction

The objective of an economic analysis of housing options for the military as conducted in Pacific Ocean Division (POD) has been to determine the most cost effective means of housing military personnel and their dependents. In a nutshell, an economic housing study looks at usually three or more alternatives to needed additional or upgraded housing, and performs an analysis of the net present value of costs of the alternatives. The calculations are performed with the POD-developed computer program, ECONS, designed especially for housing studies, although its flexibility allows for other applications in the area of benefit cost analysis. Perhaps the most unique and powerful aspect of ECONS is the ability to perform prescribed sensitivity analysis iterations, so that the validity of the outcome can be tested for its sensitivity to potential variation in the values of selected input variables or groups of variables. The program also produces certain output for graphics; study results of economic analysis of military housing alternatives are no exception to the adage, "a picture is worth a thousand words".

Outline Of The Process

The explanation of the study process will follow an actual analysis completed by POD in August, 1982. In early 1982, after having been involved in various housing studies for U.S. Forces in Korea and in Germany for the previous two years, POD was tasked with the analysis of alternatives for housing at Aberdeen Proving Ground (APG), Aberdeen, Maryland. The Family Housing Office at that U.S. Army installation had been faced with a need to do something concerning over 1,000 inadequate government owned and operated housing units for Non-Commissioned Officers (NCO) personnel and their families. Two obvious options were major renovation, and new construction. The best choice was not immediately obvious and after consulting with the Army Housing Management Office at the Office Of The Chief Of Engineers (OCE) in Washington, D.C., the APG Family Housing Officer requested POD to do the study. The study was

conducted with the advice and assistance of a consultant, Environment Capital Managers, Inc. (ECMI), of Honolulu, Hawaii. ECMI had performed previous housing studies for POD and had prepared both an ECONS users manual, and a data collection handbook for the Corps Of Engineers. The Aberdeen study was, in a sense, a field test of the users manual and data collection handbook. Both of these documents are for use in conjunction with a Department Of Army Pamphlet on the same subject.

The results of the study are summarized in Exhibits 1-6. Exhibit 1 is an Executive Summary produced for the report, to give decisionmakers a "quick and dirty" look at the results of the study. Exhibit 2 is a summary output table for the study, part of the computer output. It shows for each year the net cumulative present value (including appropriate salvage value calculations) for each of the alternatives looked at in the study. Exhibit 3 is the detailed output for the present value calculations. Exhibit 4 shows a portion of the selected sensitivity analysis output. It shows what the ranking of the alternatives was prior to the specified sensitivity test, and what the ranking was after the test was conducted (more on this later in this paper). Exhibit 5 is a portion of the report discussing the findings of the sensitivity analysis tests. Exhibit 6 shows examples of two graph formats which are part of the program output.

After a data collection field trip to Aberdeen, the basic data was formulated and organized for the present value cost calculations for the four basic alternatives of new construction, rehabilitation of existing housing, lease rental of units on the local economy, and economy housing (payment of housing allowances to the personnel involved). The summary of cost variables used for these four alternatives is shown in Exhibit 7, taken from the POD report on APG's Edgewood Family Housing Economic Analysis (a separate report was also prepared for Chesapeake Gardens, another APG housing area). Data collection involved discussions with personnel from APG's Facility Engineer, Comptroller, and Family Housing Office, as well as Real Estate Division, Baltimore District, Corps Of Engineers.

Input data for the present value calculations, sensitivity analysis, and graphics, was set up in ECONS format, as shown in Exhibit 8. In the exhibit, header information is shown through line (sequence number) 24. The cost variable input data is shown in lines 27-59. The data cover a 25 year period of analysis for the study. In line 33, the expense element for annual construction cost amounts

for new construction is shown as total annual estimates for the first four years, and twenty-one years of zero expenditures (21*0). Each of the cost variables is formatted in this way (in constant dollars).

Following the same format, input for various inflation futures to be applied to selected cost variables is shown in lines 63-72. These inflation rate guidelines were taken from Department Of Army Program Budget Committee guidance. In lines 65-66 of the input, the inflation factor variables shown mean 5.1% from year 1 to year 2, 4.73% to year 3, 4.53% to year 4, 4.44% to year 5, and 4.5% annually throughout the last 20 years of the period of analysis. Lines 75-81 show selected salvage value factors to apply if a project were terminated in a given year.

Lines 87-135 show input required for ECONS to perform the present value calculations for the selected alternatives. In the first example, the military construction alternative is based on expense items 1, 3, 4, 6, 10, 13, 17, and 20. The discount factor statement means that middle-of-year discount factors will be used to calculate present values for all eight expense elements. An indication of "*1" would have meant beginning-of-year factors and a "*3" would have meant end-of-year factors. The interest rate used is specified in line 30 as 10% per year, and includes inflation (per AR 11-28). Inflation can be excluded as in Federal water resources planning studies by using zero inflation and a lower discount rate (a rate that does not contain an inflationary component). Or the 10% rate can be used along with the statement "ADJU X", entered just before the rate statement (line 32), which will account for differential inflation only, by adjusting according to the appropriate inflation factor representative of a "general" rate of inflation (if X = 2 in the ADJU X statement, these "general" inflation factors would be taken from the second inflation factor schedule entered in the block of inflation input). The "price index" statement on line 93 indicates that the first three variables will be subject to the third inflation schedule in the inflation input (3 3 3), or the OASD(C) MILCON inflation projection, the next one is subject to the fourth inflation schedule, the next 3 are subject to the second schedule, and the last is subject to the fourth schedule. The "residual" command lines refer to the calculation of salvage value, which applies only to the first expense element (construction cost, used as a proxy for initial value). "Residual Name 2" means that the second residual factor input schedule applies. "Residual Discount 3" means that an end-of-year discount factor applies in calculating the present worth of

a salvage value. "Residual Price 3" means that the variable for the applicable salvage value is to be subject to the third inflation schedule entered. A series of commands follows for the calculations for the other three alternatives.

Lines 139-149 contain a series of commands to produce a graph summarizing the study results. The "plot" commands prescribe graph headings and tell which output results are to be graphed. The "label" commands prescribe x and y axis labelling information. The "legend" commands produce the graph legend.

The thirty-eight specifically prescribed sensitivity analysis tests are contained in lines 153-569. In the first sensitivity input command grouping (lines 153-161), the "run title" command gives the header information to be included in sensitivity analysis output. The "select iterations" command indicates that all 4 alternatives will be included in the sensitivity test. The "change" command indicates that input cost variables 1 and 2 both will be changed to check on the sensitivity of final project cost rankings to such changes. The "limit" statement indicates that sensitivity will be checked for changes from minus 100% to plus 500%. The "time" statement indicates that the period of analysis is 25 years. The "rank" statement means that the program will keep making changes to variables 1 and 2 within the plus/minus range specified in the "limit" statement until alternative 1 is the least costly. In this case, as shown in the beginning of the sensitivity analysis output shown in Exhibit 4, even if the specified variables were reduced to zero, alternative 1 would not be the least costly. The output does show that after the cost elements are reduced by 60%, alternative 2 becomes least costly. A summary of selected output results from the sensitivity tests performed is shown in Exhibit 5, a table extracted from the report.

Background And Overview Of POD's Housing Study Program

In June 1980, POD was tasked by U.S. Forces Korea (USFK) with developing an economic analysis, along with a sensitivity analysis, for 884 additional family housing requirements in Korea. A computer assisted study, using the program discussed in this paper, was conducted which resulted in the following ranking of alternatives (in order of "mission effectiveness"): (1) U.S. Government Lease

(constructed by the Korea National Housing Corporation); (2) U.S. Government Military Construction; and (3) Payment of Allowances (for procurement of economy housing). This third alternative was dropped since it would fail to provide additional housing assets. Korea already suffers from a severe shortage of available housing.

In December 1980, POD conducted additional studies for USFK, finding again that the most cost effective alternative was the U.S. Government Lease Program.

In early 1981, POD used the "know how" gained from the Korea experience to implement the program for U.S. Army, Europe (USAREUR). Studies were conducted for troop needs in Dexheim, Germany, for USAREUR's FY82 program.

Additional POD work in this area since then has involved an update of the 1980 USFK studies, the study for family housing at Aberdeen Proving Ground, and an analysis of unaccompanied housing for Fort Shafter, Hawaii (POD's offices are located at Fort Shafter). There have been indications that other branches of the service may be interested in this program.

Concluding Comment

As noted above, probably the most powerful aspect of the program ECONS is the sensitivity analysis routine. By allowing for the systematic testing of results for sensitivity to input variables, the need for extensive data support/confidence for non-sensitive input data is minimized or alleviated. Fairly large amounts of such testing can be accomplished with a great deal less effort than if a "hit or miss" piecemeal approach were used with manual calculations.

This program can be used to arrive at net benefits for other types of projects as well. The most obvious that comes to mind is Federal water and land resource planning studies. Benefit and cost input data could be formatted for a series of alternatives for a given problem or need, and ECONS could be used to calculate the net present value of the specified array of alternatives, with sensitivity analysis and graphical display of results.

There are a number of minor limitations to this computer program, and a number of changes that could make the output more useable, and the program easier to use. Its

use is now in the early stages and ECONS will undoubtedly be modified as user suggestions come forth. The housing study program will most likely also continue to grow, as evidenced in part by a training program already underway, sponsored by Huntsville Training Division, Corps Of Engineers.

Selected References

A Data Collection Handbook For The ADP Preparation Of Department Of The Army Economic And Sensitivity Analyses For Military Family Housing. Environment Capital Managers, Inc., Under Contract With The Army Corps Of Engineers. Honolulu, Hawaii. December, 1981.

A Data Collection Handbook For The ADP Preparation Of Department Of The Army Economic And Sensitivity Analyses For Military Unaccompanied Personnel Housing. Environment Capital Managers, Inc., Under Contract With The Army Corps Of Engineers. Honolulu, Hawaii. December, 1981.

A User's Manual For The ADP Preparation Of Department Of The Army Economic And Sensitivity Analyses For Family Housing Projects. Environment Capital Managers, Inc., Under Contract With The Army Corps Of Engineers. Honolulu, Hawaii. February, 1982.

A User's Manual For The ADP Preparation Of Department Of The Army Economic And Sensitivity Analyses For Unaccompanied Personnel Housing Projects. Environment Capital Managers, Inc., Under Contract With The Army Corps Of Engineers. Honolulu, Hawaii. February, 1982.

Economic Analysis, Edgewood Family Housing, Aberdeen Proving Ground, Aberdeen, Maryland. U.S. Army Corps Of Engineers, Pacific Ocean Division. May, 1982.

Economic Analysis Of Army Housing Alternatives; Concepts, Guidelines, And Formats. Draft DA Pamphlet. Army Housing Management Office, Office Of The Chief Of Engineers, Department Of The Army. September, 1981.

EXECUTIVE SUMMARY

AN ECONOMIC AND SENSITIVITY ANALYSIS OF ALTERNATIVES FOR PROVIDING FAMILY HOUSING

EDGEWOOD
FAMILY HOUSING
ABERDEEN PROVING GROUND
ABERDEEN, MARYLAND

PREPARED FOR ABERDEEN PROVING GROUND
BY
PACIFIC OCEAN DIVISION
U.S. ARMY CORPS OF ENGINEERS
BUILDING 230
FORT SHAFTER, HONOLULU, HAWAII 96858

MAY 1982

Exhibit 1

EXECUTIVE SUMMARY

The Decision Objective

The decision objective of this study has been to determine the most cost effective means of providing adequate family housing for 392 NCO personnel currently residing in inadequate off-post housing at Washington Court and Lee Court, Edgewood Arsenal area, Aberdeen Proving Ground, Aberdeen, Maryland.

Major Assumptions

Present value calculations utilized a discount rate of 10%, reflecting current policy (Army Regulation 11-28).

Future cost growth (inflation) was assumed to follow Department of the Army Program and Budget Committee (DACS-PBC) projected rates.

Structure life for both new construction and rehabilitation/expansion was assumed to be 30 years.

Expense elements which would be the same for all alternatives were not included in the analysis.

The period of analysis for the study is 25 years.

Alternative Courses of Action

Construction of New Housing Through the MCA (Military Construction Army) Family Housing Program: This would take place over a 3-year period in three phases, from FY1983 to FY1986. The site would be on-post at Edgewood Arsenal.

Rehabilitation/Expansion of Existing Housing: This would take place over a 4-year period in three phases, from FY1983 to FY1987.

Lease Rental: This would entail the block leasing of housing units on the local economy for the duration of the period of analysis.

Exhibit 1

Economy Housing: This would entail the payment of Basic Allowance for Quarters (BAQ) and Variable Housing Allowance (VHA) to the individual personnel. Housing would be obtained individually by the servicemember in the local housing market.

Economic Analysis Results

The analysis indicates that the least cost alternative is Economy Housing, with a present worth cost of $38.3 million. The present worth costs, and their respective average annual equivalent values, for the four alternatives in this analysis are:

	Present Worth	Average Annual Equivalent *
Economy Housing	$38.3 million	$4.22 million
Lease Rental	$42.2 million	$4.65 million
Rehabilitation/Expansion of Existing Units	$44.3 million	$4.88 million
New Construction	$52.9 million	$5.83 million

* Based on 25-year period of analysis, and a discount rate of 10%.

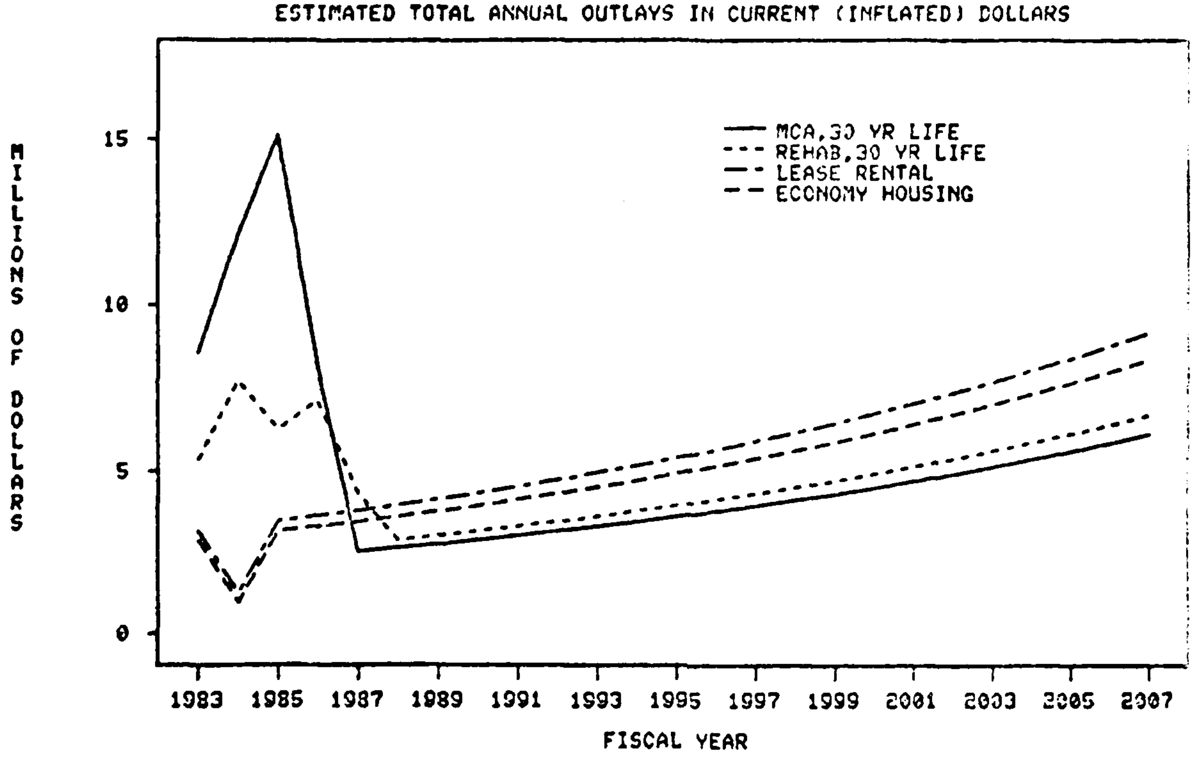
The results of the analysis are depicted graphically on the following page.

Sensitivity Analysis Results

The sensitivity analysis revealed that the lease rental course of action would be the least costly alternative if allowance payments were 14% higher, if lease rent payments were 19% lower, or if utilities costs were 45% lower. Rehabilitation/expansion would be the least cost solution if all construction cost estimates were 50% lower than estimated. Determination of the least cost alternative is not significantly sensitive to changes in any other cost element groups. Since there is some doubt regarding the local community's capability to support the requirements for military families presently residing in inadequate government quarters at Aberdeen Proving Ground, the lease rental and economy housing alternatives may not be fully realistic

Exhibit 1

GRAPHICAL DISPLAY OF RESULTS



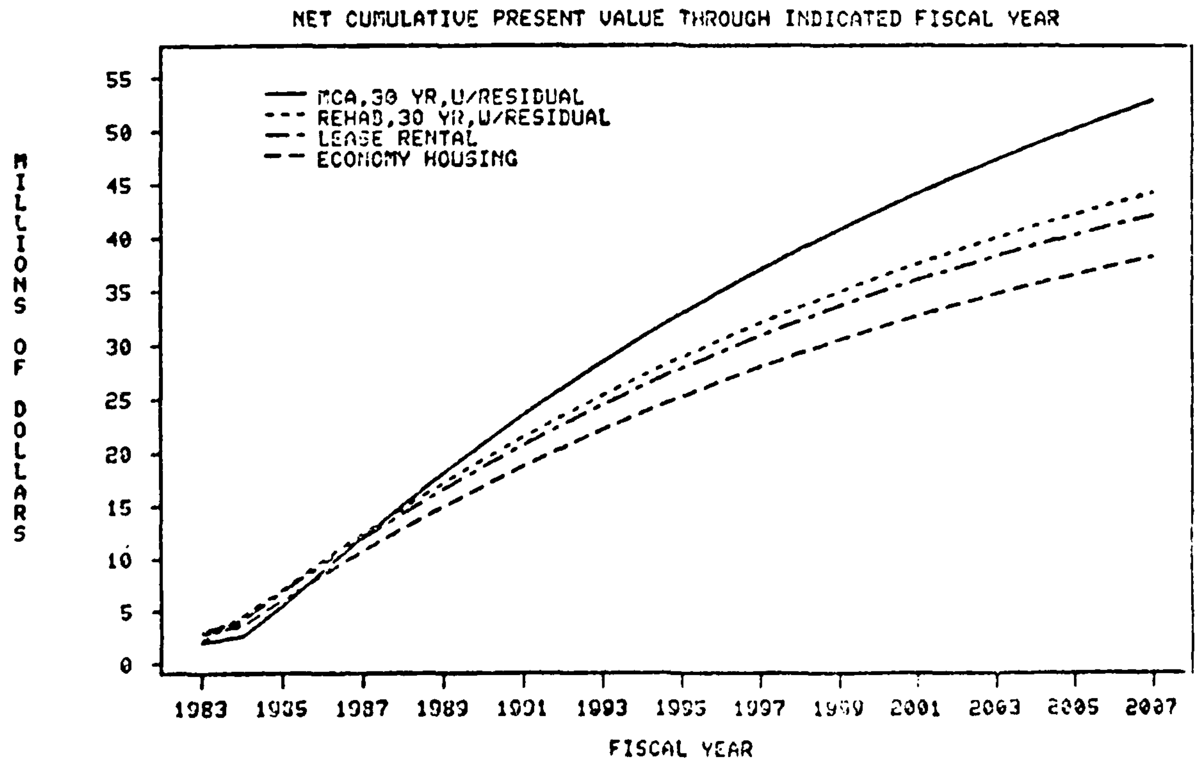


Exhibit 1

solutions. For these reasons, further sensitivity tests were conducted regarding the ranking of rehabilitation/expansion and new construction alone. Recurring expenditures for maintenance and repair and utilities for newly constructed units would have to be less than half those costs for upgraded units in the rehabilitation alternative for new construction to be less costly than rehabilitation. Similarly, if rehabilitation/expansion construction costs were to be 72% higher than estimated, or if new construction costs were to be 34% lower than estimated, new construction would be less costly.

If the rehabilitation/expansion alternative were to have a 15-year life cycle instead of 30 years as assumed in the analysis, a second rehabilitation would be required, increasing the present value of the costs by about 12% to $49.7 million.

Comment

This economic analysis alone is not a substitute for sound management judgment. It has been an attempt to systematically quantify the relevant variables involved in each of the alternative solutions for achieving the decision objective. As such, it provides documentation that economic factors bearing on the ultimate management decision have been considered. By spelling out the costs of the different alternatives, a clearer picture of the economic implications of each course of action provides management with guidance for arriving at an intelligent choice and final decision.

Economic Analysis prepared
by: William T. Hunt
Pacific Ocean Division
U.S. Army Corps of Engineers
Building 230
Fort Shafter, Hawaii 96858

Phone: Area Code 808
438-2259

E.nib t 1

SUMMARY OF ITERATIONS

** NET DISCOUNTED PRESENT VALUE **

ABERDEEN PROVING GROUNDS, MD
MILITARY FAMILY HOUSING STUDY
EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
MAY 1982

ITERATION	FY1983	FY1984	FY1985	FY1986	FY1987
30 YR MCA WITH RESID	$1,952,815	$2,584,401	$5,509,558	$8,815,219	$12,051,713
30 YR REHAB WITH RES	$2,106,811	$4,546,172	$7,035,600	$9,803,753	$12,415,216
LEASE RENTAL	$3,020,569	$4,121,045	$6,868,796	$9,479,908	$11,959,040
ECONOMY HOUSING	$2,754,553	$3,600,863	$6,106,624	$8,487,780	$10,748,580

ITERATION	FY1988	FY1989	FY1990	FY1991	FY1992
30 YR MCA WITH RESID	$15,102,098	$18,014,992	$20,795,330	$23,447,954	$25,977,611
30 YR REHAB WITH RES	$14,834,654	$17,140,221	$19,336,693	$21,428,683	$23,420,639
LEASE RENTAL	$14,314,216	$16,551,633	$18,677,179	$20,696,448	$22,614,753
ECONOMY HOUSING	$12,896,340	$14,936,711	$16,875,065	$18,716,500	$20,465,864

ITERATION	FY1993	FY1994	FY1995	FY1996	FY1997
30 YR MCA WITH RESID	$28,388,946	$30,686,498	$32,874,696	$34,974,475	$36,971,758
30 YR REHAB WITH RES	$25,316,854	$27,121,463	$28,838,451	$30,479,509	$32,039,691
LEASE RENTAL	$24,437,143	$26,168,414	$27,813,121	$29,375,593	$30,859,941
ECONOMY HOUSING	$22,127,759	$23,706,560	$25,206,421	$26,631,289	$27,984,913

ITERATION	FY1998	FY1999	FY2000	FY2001	FY2002
30 YR MCA WITH RESID	$38,885,753	$40,718,296	$42,471,322	$44,146,849	$45,759,172
30 YR REHAB WITH RES	$33,529,696	$34,951,933	$36,308,781	$37,602,582	$38,841,414
LEASE RENTAL	$32,270,072	$33,609,696	$34,882,339	$36,091,350	$37,239,910
ECONOMY HOUSING	$29,270,856	$30,492,502	$31,653,065	$32,755,601	$33,803,010

ITERATION	FY2003	FY2004	FY2005	FY2006	FY2007
30 YR MCA WITH RESID	$47,308,593	$48,795,628	$50,220,990	$51,595,507	$52,918,709
30 YR REHAB WITH RES	$40,026,674	$41,159,799	$42,242,258	$43,280,244	$44,274,557
LEASE RENTAL	$38,331,042	$39,367,618	$40,352,365	$41,287,875	$42,176,609
ECONOMY HOUSING	$34,798,048	$35,743,334	$36,641,356	$37,494,477	$38,304,942

Exhibit 2

TABLE II-1

S U M M A R Y O F C O S T S F O R E C O N O M I C A N A L Y S I S

R E P O R T B Y Y E A R

ABERDEEN PROVING GROUNDS, MD.
MILITARY FAMILY HOUSING STUDY
EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
MAY 1982

30 YR MCA WITH RESID

[illegible]	[illegible] ORGANIZATION	LOGISTICS DIRECTORATE, HOUSING DIVISION, ABERDEEN PROVING GROUNDS, MD
[illegible]	[illegible] SION	MAY 1982
[illegible]	[illegible]	ECONOMIC ANALYSIS OF FAMILY HOUSING ALTERNATIVES
4	[illegible] OF PROGRAM OBJECTIVE	PROVIDE 392 ADEQUATE FAMILY HOUSING UNITS FOR ENLISTED PERSONNEL
[illegible]	[illegible]	30 YR MCA WITH RESID
[illegible]	[illegible]	30 YEARS
7	[illegible] LYSIS	25 YEARS
[illegible]	[illegible]	1983
[illegible]	[illegible]	1983

Exhibit 3

TABLE II-1 (continued)
(MCA)

P R O J E C T / P R O G R A M   C O S T S

YEAR	[illegible] LIFE (01)	LAND AQUISITION EA (03)	PRPTY DSPSL EXSTG UNITS EA (04)	ALLOWANCES (MCA) EA (05)	MNT AND RPR MCA EA (10)	UTILITIES MCA EA (13)	SERVICES MCA EA (17)	ADMIN (MCA AND REHAB) EA (20)
[illegible]	[illegible]	$0	$0	$0	$0	$739,000	$101,000	[illegible]
[illegible]	$10,317,[illegible]	$0	-$2,059,960	$0	$100,596	$733,565	$106,151	[illegible]
[illegible]	$15,01[illegible]	$0	$0	$0	$287,285	$740,424	$111,171	[illegible]
[illegible]	$5,704,54[illegible]	$0	$0	$0	$492,445	$739,819	$116,208	[illegible]
[illegible]	$0	$0	$0	$0	$598,426	$754,642	$121,367	[illegible]
[illegible]	$0	$0	$0	$0	$625,355	$783,601	$126,829	$1,117,6[illegible]
[illegible]	$0	$0	$0	$0	$653,496	$824,088	$132,536	[illegible]
[illegible]	$0	$0	$0	$0	$682,904	$851,172	$138,500	[illegible]
[illegible]	$0	$0	$0	$0	$713,634	$899,925	$144,703	$1,275,371
[illegible]	$0	$0	$0	$0	$745,748	$940,421	$151,346	[illegible]
[illegible]	$0	$0	$0	$0	$779,307	$982,740	$158,052	[illegible]
[illegible]	$0	$0	$0	$0	$814,375	$1,026,964	$165,164	[illegible]
[illegible]	$0	$0	$0	$0	$851,023	$1,073,177	$172,597	[illegible]
[illegible]	$0	$0	$0	$0	$889,319	$1,121,470	$180,243	[illegible]
[illegible]	$0	$0	$0	$0	$929,338	$1,171,936	$188,430	[illegible]
[illegible]	$0	$0	$0	$0	$971,158	$1,224,673	$196,961	[illegible]
[illegible]	$0	$0	$0	$0	$1,014,860	$1,279,704	$205,825	[illegible]
[illegible]	$0	$0	$0	$0	$1,060,509	$1,337,374	$215,007	[illegible]
[illegible]	$0	$0	$0	$0	$1,108,283	$1,397,556	[illegible]	[illegible]
[illegible]	$0	$0	$0	$0	$1,158,124	$1,460,446	$234,[illegible]	[illegible]
[illegible]	$0	$0	$0	$0	$1,210,240	$1,526,166	$245,450	[illegible]
[illegible]	$0	$0	$0	$0	$1,264,701	$1,594,344	$255,495	[illegible]
[illegible]	$0	$0	$0	$0	$1,321,612	$1,666,612	$263,037	[illegible]
[illegible]	$0	$0	$0	$0	$1,381,055	$1,741,609	$280,077	[illegible]
[illegible]	$0	$0	$0	$0	$1,443,234	$1,819,981	$292,704	[illegible]

Exhibit 3

TABLE II-1 (continued)
(MCA)

PROJECT / PROGRAM COSTS

YEAR	TOTAL ANNUAL OUTLAYS	DISCOUNTED PRESENT VALUE	CUMULATIVE DISCOUNTED PV	DISCOUNTED P.V. RESIDUAL	CUMULATIVE NET DISC P.V.
[illegible]	[illegible]	$8,167,360	$8,167,360	$6,214,545	$1,952,815
[illegible]	$12,[illegible],763	$10,534,690	$18,702,050	$16,117,649	$2,584,401
[illegible]	[illegible]	$11,931,204	$30,633,254	$25,123,696	$5,509,558
[illegible]	[illegible]	$5,785,987	$36,419,242	$27,604,022	$8,815,219
[illegible]	[illegible],914	$1,656,667	$38,075,909	$26,024,196	$12,051,713
[illegible]	[illegible],390	$1,573,834	$39,649,744	$24,547,666	$15,102,078
[illegible]	[illegible]	$1,495,122	$41,144,866	$23,129,874	$18,014,992
[illegible]	[illegible]	$1,420,406	$42,565,272	$21,769,942	$20,795,330
[illegible]	[illegible]	$1,349,366	$43,914,638	$20,466,634	$23,447,904
[illegible]	[illegible],180	$1,281,897	$45,196,535	$19,218,925	$25,977,611
[illegible]	[illegible]	$1,217,803	$46,414,339	$18,025,393	$28,388,946
[illegible]	[illegible],451,515	$1,156,912	$47,571,252	$16,884,754	$30,686,498
[illegible]	[illegible],617,722	$1,099,067	$48,670,319	$15,795,623	$32,874,696
[illegible]	[illegible]	$1,044,113	$49,714,433	$14,739,957	$34,974,475
[illegible]	[illegible]	$991,908	$50,706,341	$13,734,583	$36,971,758
[illegible]	[illegible]	$942,312	$51,648,654	$12,762,900	$38,885,753
[illegible]	[illegible],177	$895,197	$52,543,851	$11,825,554	$40,718,296
[illegible]	[illegible],315	$850,437	$53,394,288	$10,922,965	$42,471,322
[illegible]	$4,711,189	$807,915	$54,202,204	$10,055,354	$44,146,849
[illegible]	[illegible],192	$767,519	$54,969,723	$9,210,550	$45,759,172
[illegible]	$5,141,726	$729,143	$55,698,867	$8,390,274	$47,308,593
[illegible]	[illegible]	$692,686	$56,391,553	$7,595,925	$48,795,628
[illegible]	[illegible]	$658,052	$57,049,605	$6,828,615	$50,220,990
[illegible]	[illegible]	$625,149	$57,674,755	$6,079,248	$51,595,507
[illegible]	$5,135,193	$593,892	$58,268,647	$5,349,937	$52,918,709

MCA Average Annual Equivalent Amount = $5,829,952 (10%, 25 Years)

Exhibit 3

TABLE II-1 (continued)

S U M M A R Y   O F   C O S T S   F O R   E C O N O M I C   A N A L Y S I S

R E P O R T   B Y   Y E A R

ABERDEEN PROVING GROUNDS, MD.
MILITARY FAMILY HOUSING STUDY
EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
MAY 1982

30 YEAR REHAB WITH RESID

1.	SUBMITTING ORGANIZATION	LOGISTICS DIRECTORATE, HOUSING DIVISION, ABERDEEN PROVING GROUNDS, MD
2.	DATE OF SUBMISSION	MAY 1982
3.	PROJECT TITLE	ECONOMIC ANALYSIS OF FAMILY HOUSING ALTERNATIVES
4.	DESCRIPTION OF PROGRAM OBJECTIVE	PROVIDE 392 ADEQUATE FAMILY HOUSING UNITS FOR ENLISTED PERSONNEL
5.	ALTERNATIVE	30 YR REHAB WITH RESID
6.	ECONOMIC LIFE	30 YEARS
7.	PERIOD OF ANALYSIS	25 YEARS
8.	BASE YEAR	1983
9.	STARTING YEAR	1983

Exhibit 3

TABLE II-1 (continued)
(Rehabilitation/Expansion)

PROJECT / PROGRAM COSTS

YEAR	[illegible] 30 YR LIFE [illegible] (02)	[illegible] AQUISITION EA (03)	ALLOWANCES 30 YR REHAB EA (07)	MNT AND RPR 30 YR REHAB EA (12)	UTILITIES 30 YR REHAB EA (14)	SERVICES 30 YR REHAB EA (18)	ADMIN (NON AND REHAB) EA (20)	[illegible] ANNUAL OUTLAYS (
[illegible]	[illegible]	$0	$547,000	$0	$545,000	$75,000	$890,000	[illegible]
[illegible]	[illegible]	$0	$678,635	$69,366	$465,573	$84,111	$935,370	$7,740,614
[illegible]	$3,[illegible]	$0	$556,679	$289,487	$605,391	$83,553	$979,533	$6,[illegible],970
[illegible]	$4,[illegible]	$0	$711,035	$474,036	$598,298	$91,690	$1,034,011	$7,152,[illegible]
[illegible]	$1,4[illegible]	$0	$247,541	$634,476	$800,305	$109,351	$1,069,477	$4,044,[illegible]
[illegible]	$0	$0	$0	$735,860	$927,988	$126,629	$1,117,603	$2,905,231
[illegible]	$0	$0	$0	$769,974	$969,747	$132,536	$1,167,895	$3,039,154
[illegible]	$0	$0	$0	$803,573	$1,013,386	$138,500	$1,220,451	$3,175,916
[illegible]	$0	$0	$0	$839,739	$1,058,983	$144,722	$1,275,371	[illegible]
[illegible]	$0	$0	$0	$877,507	$1,106,642	$151,246	$1,332,760	[illegible]
[illegible]	$0	$0	$0	$917,016	$1,156,441	$158,052	$1,392,737	$3,624,[illegible]
[illegible]	$0	$0	$0	$953,231	$1,208,481	$165,164	$1,455,411	$3,787,[illegible]
[illegible]	$0	$0	$0	$1,001,404	$1,262,863	$172,577	$1,520,904	$3,[illegible],769
[illegible]	$0	$0	$0	$1,046,467	$1,319,692	$180,363	$1,589,345	$4,135,869
[illegible]	$0	$0	$0	$1,093,553	$1,379,078	$188,480	$1,660,865	$4,321,[illegible]
[illegible]	$0	$0	$0	$1,142,763	$1,441,136	$196,961	$1,735,604	$4,516,472
[illegible]	$0	$0	$0	$1,194,193	$1,505,988	$205,825	$1,813,[illegible]	$4,719,713
[illegible]	$0	$0	$0	$1,247,932	$1,573,757	$215,087	$1,895,223	$4,932,101
[illegible]	$0	$0	$0	$1,304,087	$1,644,576	$224,766	$1,980,613	$5,154,[illegible]
[illegible]	$0	$0	$0	$1,362,773	$1,718,582	$234,800	$2,069,740	$5,[illegible]
[illegible]	$0	$0	$0	$1,424,098	$1,795,918	$245,450	$2,162,879	$5,[illegible]
[illegible]	$0	$0	$0	$1,488,152	$1,876,735	$256,495	$2,260,208	$5,[illegible]
[illegible]	$0	$0	$0	$1,555,150	$1,961,188	$268,037	$2,361,918	$6,146,295
[illegible]	$0	$0	$0	$1,625,132	$2,049,441	$280,099	$2,468,304	$6,[illegible]
[illegible]	$0	$0	$0	$1,698,263	$2,141,666	$292,704	$2,579,273	$6,711,[illegible]

Exhibit 3

TABLE II-1 (continued)
(Rehabilitation/Expansion)

PROJECT / PROGRAM COSTS

[illegible]	DI[illegible]D [illegible]	CUMULATIVE DISCOUNTED P V	DISCOUNTED P V RESIDUAL	CUMULATIVE NET DISC P V
[illegible]	[illegible]	$5,033,629	$2,931,818	$2,106,811
[illegible]	$[illegible],443	$11,753,072	$7,211,900	$4,576,172
19[illegible]	$4,[illegible]	$16,753,421	$9,722,220	$7,035,600
[illegible]	[illegible]	[illegible]	$12,070,010	$9,093,753
[illegible]	[illegible]	$24,711,493	$12,296,[illegible]	$12,413,216
[illegible]	[illegible]	$[illegible],453,274	$11,578,620	$14,634,604
[illegible]	[illegible]	$[illegible],068,951	$10,903,740	$17,140,221
[illegible]	[illegible]	[illegible]	$10,205,171	$19,336,693
[illegible]	[illegible]	$31,099,072	$9,670,339	$21,439,683
[illegible]	[illegible]	$[illegible],181,470	$9,010,800	$23,429,609
[illegible]	[illegible]	$33,300,743	$8,516,073	$25,316,054
[illegible]	[illegible]	$[illegible],299,211	$7,917,443	$27,121,463
[illegible]	[illegible]	[illegible]	$7,423,040	$28,[illegible]
[illegible]	[illegible]	$37,444,053	$6,954,044	$30,479,507
[illegible]	$1,[illegible],143	$38,539,202	$6,437,510	$32,059,691
[illegible]	$1,[illegible],871	$39,560,093	$6,030,396	$33,529,696
[illegible]	[illegible],346	$40,527,439	$5,587,506	$34,951,933
[illegible]	[illegible]	$41,437,819	$5,161,020	$36,303,781
[illegible]	[illegible]	$42,350,679	$4,751,076	$37,602,102
[illegible]	[illegible]	$43,143,342	$4,311,931	$38,941,414
[illegible]	[illegible]	$43,991,030	$3,954,385	$40,037,674
[illegible]	[illegible]	$44,748,027	$3,539,010	$41,159,799
[illegible]	[illegible]	$45,450,739	$3,226,431	$42,242,258
[illegible]	[illegible],914	$46,150,653	$2,672,409	$43,230,244
[illegible]	[illegible],718	$46,803,372	$2,527,814	$44,274,557

Rehabilitation/Expansion Average Annual Equivalent Amount = $4,877,642 (10%, 25 years)

Exhibit 3

TABLE II-1 (continued)

S U M M A R Y   O F   C O S T S   F O R   E C O N O M I C   A N A L Y S I S

R E P O R T   B Y   Y E A R

ABERDEEN PROVING GROUNDS, MD
MILITARY FAMILY HOUSING STUDY
EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
MAY 1982

LEASE RENTAL

1	SUBMITTING ORGANIZATION	LOGISTICS DIRECTORATE, HOUSING DIVISION, ABERDEEN PROVING GROUNDS, MD
2	DATE OF SUBMISSION	MAY 1982
3	PROJECT TITLE	ECONOMIC ANALYSIS OF FAMILY HOUSING ALTERNATIVES
4	DESCRIPTION OF PROGRAM OBJECTIVE	PROVIDE 392 ADEQUATE FAMILY HOUSING UNITS FOR ENLISTED PERSONNEL
5	ALTERNATIVE	LEASE RENTAL
6	ECONOMIC LIFE	NOT APPLICABLE
7	PERIOD OF ANALYSIS	25 YEARS
8	BASE YEAR	1983
9	STARTING YEAR	1983

Exhibit 3

TABLE II-1 (continued)
(Lease Rental)

PROJECT / PROGRAM COSTS

YEAR	[illegible] EXIST UNITS EA (04)	LEASE RENTAL EA (05)	ALLOWANCES (LEASE) EA (08)	MNT AND RPR (LEASE) EA (11)	UTILITIES (LEASE) EA (15)	SERVICES (LEASE) EA (16)	CONTR ADMIN (LEASE) EA (19)	ADMIN (L[illegible] AND [illegible] EA (21)
1983	$0	$1,543,000	$0	$51,000	$[illegible]8,000	$101,000	$44,000	$[illegible]01,000
1984	-$1,059,960	$1,621,5[illegible]2	$0	$53,601	$[illegible]0,027	$106,151	$46,244	$841,850
1985	$0	$1,[illegible]	$0	$56,126	$[illegible]1,747	$111,171	$48,421	$[illegible]01,670
1986	$0	$1,775,[illegible]	$0	$58,679	$722,540	$116,208	$50,625	$[illegible]
1987	$0	$1,[illegible] 151	$0	$61,204	$714,642	$121,347	$52,573	$[illegible]
1988	$0	$1,937,[illegible]3	$0	$64,042	$785,601	$126,829	$55,252	$1,[illegible]
1989	$0	$2,071,770	$0	$66,924	$824,088	$132,536	$57,733	$1,051,1[illegible]
1990	$0	$2,115,906	$0	$69,935	$861,172	$138,500	$60,326	$1,09[illegible]
1991	$0	$2,211,1[illegible]	$0	$73,033	$899,925	$144,733	$63,052	$1,147,[illegible]4
1992	$0	$2,310,6[illegible]	$0	$76,371	$940,421	$151,246	$65,857	$1,19[illegible]
1993	$0	$2,414,600	$0	$79,808	$982,740	$158,052	$68,854	$1,2[illegible]
1994	$0	$2,5[illegible]7	$0	$83,397	$1,026,964	$165,164	$71,952	$1,[illegible]
1995	$0	$2,6[illegible]834	$0	$87,152	$1,073,177	$172,597	$75,190	$1,[illegible]814
1996	$0	$2,755,[illegible]	$0	$91,074	$1,121,470	$180,363	$78,574	$1,[illegible]
1997	$0	$2,879,455	$0	$95,173	$1,171,936	$188,480	$82,110	$1,49[illegible],779
1998	$0	$3,009,031	$0	$99,456	$1,224,673	$196,961	$85,805	$1,[illegible]
1999	$0	$3,144,[illegible]	$0	$103,931	$1,279,784	$205,825	$89,666	$1,6[illegible]
2000	$0	$3,[illegible]7	$0	$108,608	$1,337,374	$215,037	$93,701	$1,7[illegible],791
2001	$0	$3,[illegible]	$0	$113,495	$1,397,556	$224,766	$97,917	$1,[illegible]
2002	$0	$3,[illegible]	$0	$118,603	$1,460,446	$234,880	$102,324	$1,[illegible]
2003	$0	$3,749,800	$0	$123,940	$1,526,166	$245,450	$106,928	$1,94[illegible]
2004	$0	$3,918,541	$0	$129,517	$1,594,844	$256,495	$111,740	$2,034,1[illegible]7
2005	$0	$4,094,876	$0	$135,345	$1,666,612	$268,037	$116,768	$2,1[illegible]
2006	$0	$4,279,145	$0	$141,436	$1,741,609	$280,079	$122,023	$2,221,3[illegible]4
2007	$0	$4,471,707	$0	$147,801	$1,819,981	$292,704	$127,514	$2,321,3[illegible]6

Exhibit 3

TABLE II-1 (continued)
(Lease Rental)

PROJECT / PROGRAM COSTS

YEAR	TOTAL ANNUAL OUTLAYS	DISCOUNTED PRESENT VALUE	CUMULATIVE NET DISC P.V.
1983	[illegible]	$3,020,569	$3,020,569
1984	[illegible]	$1,100,476	$4,121,045
1985	[illegible]	$2,747,750	$6,868,796
1986	[illegible]	$2,611,112	$9,479,908
1987	[illegible]	$2,479,132	$11,959,040
1988	$3,970,167	$2,355,175	$14,314,216
1989	$4,157,105	$2,237,416	$16,551,633
1990	[illegible]	$2,125,546	$18,677,179
1991	[illegible]	$2,019,268	$20,696,448
1992	[illegible]	$1,918,305	$22,614,753
1993	[illegible]	$1,822,390	$24,427,143
1994	[illegible]	$1,731,270	$26,163,414
1995	[illegible]	$1,644,707	$27,813,121
1996	[illegible]	$1,562,471	$29,375,593
1997	$5,911,935	$1,484,348	$30,859,941
1998	$6,177,972	$1,410,130	$32,270,072
1999	[illegible]	$1,339,624	$33,607,696
2000	[illegible]	$1,272,643	$34,882,339
2001	[illegible]	$1,209,010	$36,091,350
2002	$7,257,047	$1,148,560	$37,239,910
2003	[illegible]	$1,091,132	$38,331,042
2004	[illegible]	$1,036,575	$39,367,618
2005	[illegible]	$984,746	$40,352,365
2006	[illegible]	$935,509	$41,287,875
2007	[illegible]	$888,734	$42,176,609

Lease Rental Average Annual Equivalent Amount = $4,646,516 (10%, 25 years)

Exhibit 3

TABLE II-1 (continued)

SUMMARY OF COSTS FOR ECONOMIC ANALYSIS

REPORT BY YEAR

ABERDEEN PROVING GROUNDS, MD.
MILITARY FAMILY HOUSING STUDY
EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
MAY 1982

ECONOMY HOUSING

1	SUBMITTING ORGANIZATION	LOGISTICS DIRECTORATE, HOUSING DIVISION, ABERDEEN PROVING GROUNDS, MD
2	DATE OF SUBMISSION	MAY 1982
3	PROJECT TITLE	ECONOMIC ANALYSIS OF FAMILY HOUSING ALTERNATIVES
4	DESCRIPTION OF PROGRAM OBJECTIVE	PROVIDE 392 ADEQUATE FAMILY HOUSING UNITS FOR ENLISTED PERSONNEL
5	ALTERNATIVE	ECONOMY HOUSING
6	ECONOMIC LIFE	NOT APPLICABLE
7	PERIOD OF ANALYSIS	25 YEARS
8	BASE YEAR	1983
9	STARTING YEAR	1983

Exhibit 3

TABLE II-1 (continued)
(Economy Housing)

P R O J E C T / P R O G R A M C O S T S

PACE 001

[illegible]	[illegible] (04)	ALLOWANCES (ECONOMY) EA (09)	ADMIN (LSE AND ECON) EA (21)	TOTAL ANNUAL OUTLAYS (	DISCOUNTED PRESENT VALUE	CUMULATIVE NET DISC P. V.
[illegible]	$0	$2,028,000	$861,000	$2,889,000	$2,754,553	$2,754,553
[illegible]	-$2,057,960	$2,194,487	$841,050	$976,378	$846,309	$3,600,863
[illegible]	$0	$2,293,237	$881,670	$3,179,957	$2,505,761	$6,106,624
[illegible]	$0	$2,402,299	$921,610	$3,324,009	$2,331,156	$8,437,780
[illegible]	$0	$2,509,066	$962,529	$3,471,595	$2,280,799	$10,718,580
[illegible]	$0	$2,621,974	$1,005,843	$3,627,817	$2,147,759	$12,896,340
[illegible]	$0	$2,737,962	$1,051,106	$3,791,069	$2,040,371	$14,926,711
[illegible]	$0	$2,863,261	$1,098,406	$3,961,667	$1,938,353	$16,875,065
[illegible]	$0	$2,992,103	$1,147,834	$4,137,942	$1,841,435	$18,716,500
[illegible]	$0	$3,126,753	$1,197,487	$4,325,240	$1,749,363	$20,465,864
[illegible]	$0	$3,267,456	$1,253,464	$4,520,920	$1,661,895	$22,127,759
[illegible]	$0	$3,414,492	$1,307,869	$4,724,362	$1,578,800	$23,705,560
[illegible]	$0	$3,553,144	$1,363,814	$4,935,958	$1,499,860	$25,206,421
[illegible]	$0	$3,728,711	$1,430,410	$5,159,121	$1,424,837	$26,631,239
[illegible]	$0	$3,896,503	$1,494,779	$5,391,282	$1,353,624	$27,984,913
[illegible]	$0	$4,071,845	$1,562,044	$5,633,890	$1,235,943	$29,270,856
[illegible]	$0	$4,255,078	$1,622,336	$5,837,415	$1,221,645	$30,492,502
[illegible]	$0	$4,445,557	$1,705,791	$6,152,348	$1,160,563	$31,653,065
[illegible]	$0	$4,645,652	$1,782,552	$6,429,204	$1,102,535	$32,755,601
[illegible]	$0	$4,855,751	$1,862,766	$6,718,518	$1,047,403	$33,803,010
[illegible]	$0	$5,074,260	$1,946,591	$7,020,852	$995,038	$34,798,048
[illegible]	$0	$5,302,602	$2,034,137	$7,336,750	$945,286	$35,743,334
[illegible]	$0	$5,541,219	$2,125,726	$7,666,945	$893,022	$36,641,356
[illegible]	$0	$5,790,574	$2,221,384	$8,011,958	$853,120	$37,494,477
2007	$0	$6,051,150	$2,321,346	$8,372,496	$810,464	$38,304,942

Economy Housing Average Annual Equivalent Amount = $4,219,982 (10%, 25 years)

Exhibit 3

S E N S I T I V I T Y   A N A L Y S I S

R A N K I N G

ABERDEEN PROVING GROUNDS, MD.
MILITARY FAMILY HOUSING STUDY
EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
MAY 1982

NO	001
TITLE	% CHANGE IN CONSTRUCTION COSTS (BOTH MCA AND REHAB) FOR MCA TO BE LEAST COST
SELECTED ITERATIONS	1 2 3 4
COST ITEMS TO CHANGE	1 2
ALLOWABLE CHANGE	500.00 PERCENT
TIME PERIOD	25 YEARS
TRACE	OFF
OBJECTIVE	RANK ITERATION 1 FIRST

INITIAL RANKING		FINAL RANKING	
ITERATION	NET DISCOUNTED P.V.	ITERATION	NET DISCOUNTED P.V.
4	$38,304,942	2	$38,177,819
3	$42,176,609	4	$38,304,942
2	$44,274,557	1	$39,825,366
1	$52,918,709	3	$42,176,609

COST ITEMS REDUCED TO ZERO - INSENSITIVE
** PERCENTAGE AT END = -60.00

Exhibit 4

TABLE II-2

REQUIRED CHANGE IN COST ELEMENTS TO ALTER RANKINGS

Cost Element Category	Required Change[1/] New Construction	Rehabilitation	Lease Rental
Construction Costs (Variables 1 & 2)	*	-50%	*
Property Disposal (Variable 4)	*	*	*
Lease Rental (Variable 5)	*	*	-19%
Allowances (Variables 6, 7, 8, 9)	*	*	+14%
Maintenance & Repair (Variables 10, 11, 12)	*	*	*
Utilities (Variables 13, 14, 15)	*	*	-45%
Services (Variables 16, 17, 18)	*	*	*
Contract Administration (Variable 19)	*	*	*
Administration (Variables 20 & 21)	*	*	*

1/ Change in cost element which would result in indicated alternative being the least costly alternative.

* Insensitive: A change in the selected cost element group within the range of -100% to +500% would not result in the indicated alternative becoming the least costly alternative.

There is some doubt that the local community is capable of supporting the housing requirements for military families presently residing in inadequate quarters at Aberdeen Proving Ground (see Appendix D, p. D-1, regarding DD Form 1379). For this reason, the lease rental and economy housing alternatives may not be fully realistic solutions to the objective of this housing study. In view of this consideration, additional tests were conducted regarding the sensitivity of the ranking of just the rehabilitation/expansion and new construction alternatives. Table II-3 summarizes the results of these sensitivity tests.

Exhibit 5

TABLE II-3

SENSITIVITY TESTS, REHABILITATION/EXPANSION AND NEW CONSTRUCTION

Cost Element Category	Required Change 1/
Rehabilitation/Expansion Construction Costs (Variable 2)	+72%
MCA Construction Costs (Variable 1)	-34%
MCA Maintenance and Repair (Variable 10)	2/
MCA Utilities (Variable 13)	2/
MCA Maintenance and Repair and Utilities (Variables 10 and 13)	-59%

1/ Change in cost element which would result in new construction (MCA) being less costly than rehabilitation/expansion.

2/ The rank order of the two alternatives is insensitive to this variable. Even if maintenance and repair or utilities costs for new construction units were zero for the entire period of analysis, rehabilitation/-expansion would still be less costly.

Table II-3 reveals that significant changes in key cost elements would have to take place in order for the new construction alternative to be less costly than rehabilitation/expansion of existing units. In the analysis which produced the initial rankings, the recurring annual cost elements of maintenance and repair, and utilities, were assumed to be 15% less for new construction units than for either existing or renovated units. The required percentage change figures in Table II-3 refer to further reduction, in addition to the assumed 15%, for the applicable cost elements.

Exhibit 5

GRAPHICAL DISPLAY OF RESULTS
NET PRESENT VALUE, FY 83 THROUGH INDICATED FISCAL YEAR

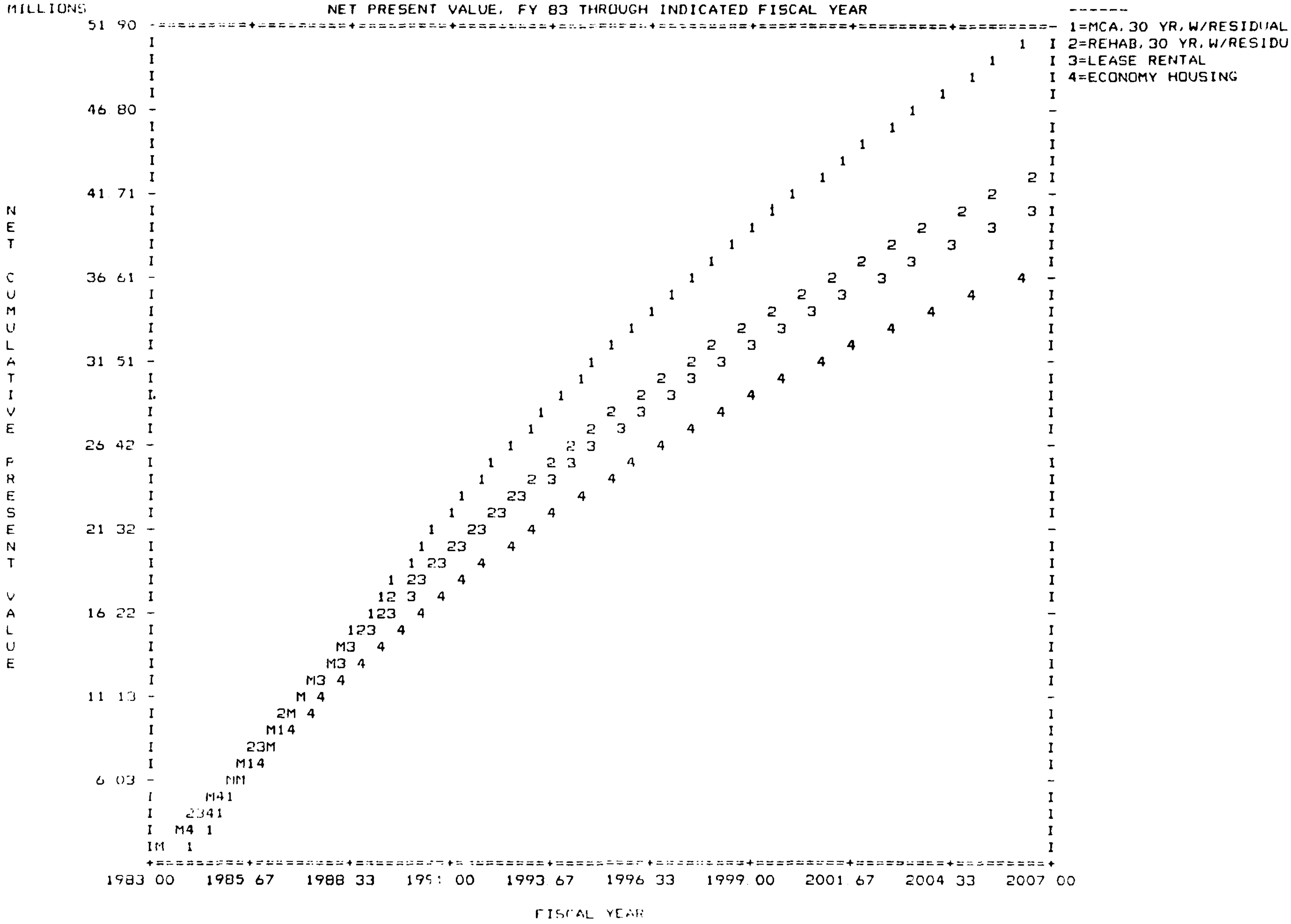


Exhibit 6

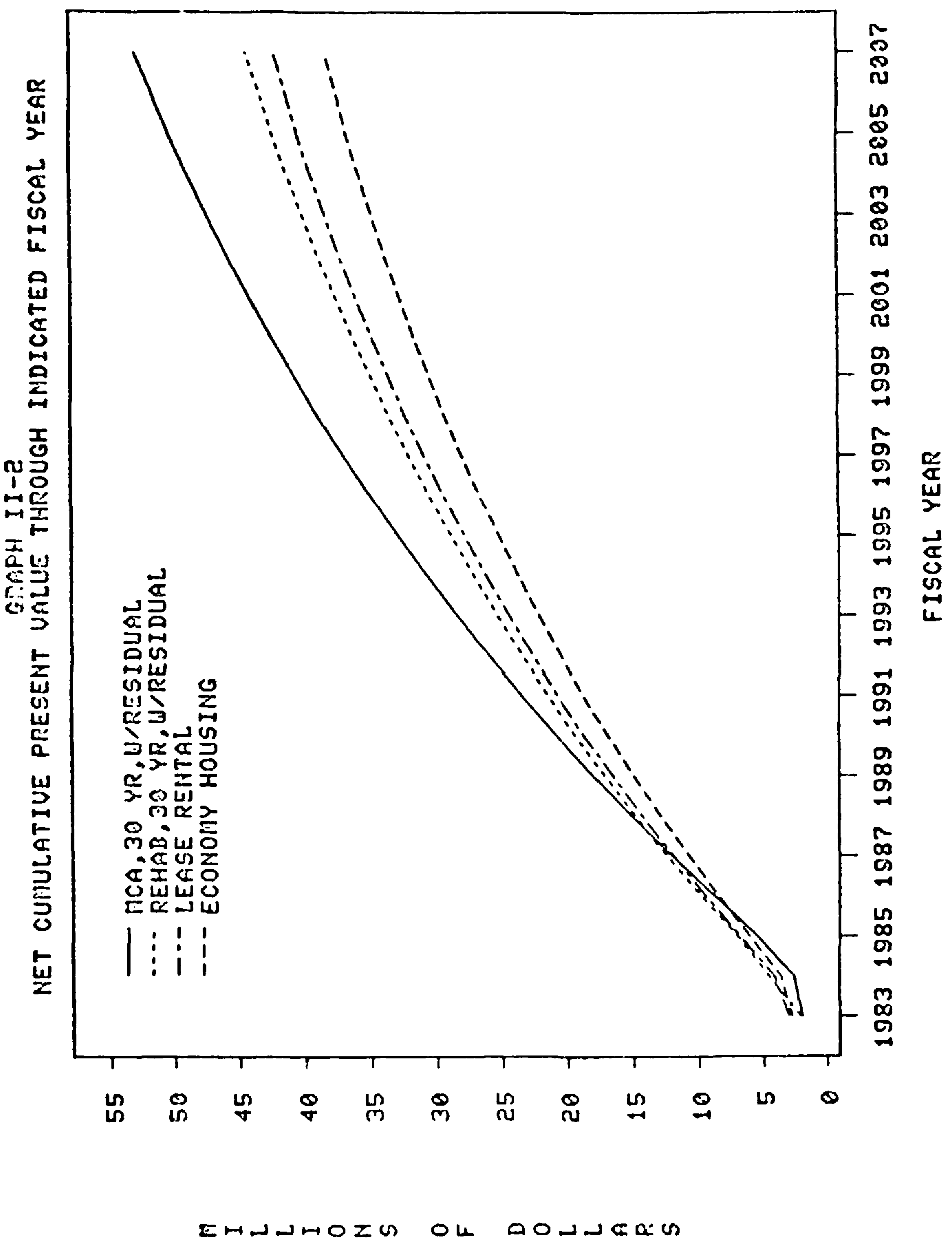

GRAPH II-2
NET CUMULATIVE PRESENT VALUE THROUGH INDICATED FISCAL YEAR
MCA,30 YR,W/RESIDUAL
REHAB,30 YR,W/RESIDUAL
LEASE RENTAL
ECONOMY HOUSING
55
50
45
40
35
30
25
20
15
10
5
0
1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007
FISCAL YEAR
MILLIONS OF DOLLARS

Exhibit 6

TABLE A-1
COST ELEMENT MATRIX SUMMARY
($1,000's)*

FISCAL YEAR	CONSTRUCTION COST MCA	REHABILITATION COST	LAND ACQUISITION	PROPERTY DISPOSAL EXISTING UNITS	LEASE RENTAL	ALLOWANCE MCA	ALLOWANCES REHABILITATION	ALLOWANCES LEASE	ALLOWANCES ECONOMY
1983	6,836	3,280	0	0	1,543	0	547	0	2,088
1984	11,720	5,069	0	-1,960	1,543	0	836	0	2,088
1985	11,824	3,408	0	0	1,543	0	533	0	2,088
1986	4,958	3,706	0	0	1,543	0	618	0	2,088
1987	0	1,234	0	0	1,543	0	206	0	2,088
1988	0	0	0	0	1,543	0	0	0	2,088
1989	0	0	0	0	1,543	0	0	0	2,088
1990	0	0	0	0	1,543	0	0	0	2,088
1991	0	0	0	0	1,543	0	0	0	2,088
1992	0	0	0	0	1,543	0	0	0	2,088
1993	0	0	0	0	1,543	0	0	0	2,088
1994	0	0	0	0	1,543	0	0	0	2,088
1995	0	0	0	0	1,543	0	0	0	2,088
1996	0	0	0	0	1,543	0	0	0	2,088
1997	0	0	0	0	1,543	0	0	0	2,088
1998	0	0	0	0	1,543	0	0	0	2,088
1999	0	0	0	0	1,543	0	0	0	2,088
2000	0	0	0	0	1,543	0	0	0	2,088
2001	0	0	0	0	1,543	0	0	0	2,088
2002	0	0	0	0	1,543	0	0	0	2,088
2003	0	0	0	0	1,543	0	0	0	2,088
2004	0	0	0	0	1,543	0	0	0	2,088
2005	0	0	0	0	1,543	0	0	0	2,088
2006	0	0	0	0	1,543	0	0	0	2,088
2007	0	0	0	0	1,543	0	0	0	2,088

*Amounts reflect estimated October 1983 price levels.

Exhibit 7

TABLE A-1 (continued)
COST ELEMENT MATRIX SUMMARY
($1,000's)*

FISCAL YEAR	MAINTENANCE AND REPAIR MCA	MAINTENANCE AND REPAIR REHABILITATION	MAINTENANCE AND REPAIR LEASE	UTILITIES MCA	UTILITIES REHABILITATION
1983	0	0	51	739	545
1984	96	66	51	717	443
1985	261	263	51	680	550
1986	428	412	51	643	520
1987	498	528	51	628	666
1988	498	586	51	628	739
1989	498	586	51	628	739
1990	498	586	51	628	739
1991	498	586	51	628	739
1992	498	586	51	628	739
1993	498	586	51	628	739
1994	498	586	51	628	739
1995	498	586	51	628	739
1996	498	586	51	628	739
1997	498	586	51	628	739
1998	498	586	51	628	739
1999	498	586	51	628	739
2000	498	586	51	628	739
2001	498	586	51	628	739
2002	498	586	51	628	739
2003	498	586	51	628	739
2004	498	586	51	628	739
2005	498	586	51	628	739
2006	498	586	51	628	739
2007	498	586	51	628	739

*Amounts reflect estimated October 1983 price levels.

TABLE A-1 (continued)
COST ELEMENT MATRIX SUMMARY
($1,000's)*

FISCAL YEAR	UTILITIES LEASE	SERVICES MCA	SERVICES REHABILITATION	SERVICES LEASE	CONTRACT ADMINISTRATION LEASE	ADMINISTRATION MCA AND REHABILITATION	ADMINISTRATION LEASE AND ECONOMY
1983	628	101	75	101	44	890	801
1984	628	101	61	101	44	890	801
1985	628	101	75	101	44	890	801
1986	628	101	71	101	44	890	801
1987	628	101	91	101	44	890	801
1988	628	101	101	101	44	890	801
1989	628	101	101	101	44	890	801
1990	628	101	101	101	44	890	801
1991	628	101	101	101	44	890	801
1992	628	101	101	101	44	890	801
1993	628	101	101	101	44	890	801
1994	628	101	101	101	44	890	801
1995	628	101	101	101	44	890	801
1996	628	101	101	101	44	890	801
1997	628	101	101	101	44	890	801
1998	628	101	101	101	44	890	801
1999	628	101	101	101	44	890	801
2000	628	101	101	101	44	890	801
2001	628	101	101	101	44	890	801
2002	628	101	101	101	44	890	801
2003	628	101	101	101	44	890	801
2004	628	101	101	101	44	890	801
2005	628	101	101	101	44	890	801
2006	628	101	101	101	44	890	801
2007	628	101	101	101	44	890	801

*Amounts reflect October 1983 price levels.

Exhibit 7

```
SEQUENCE  COMMAND
NUMBER    NUMBER               COMMAND
------    ------    ---------------------------------------------------------------------------
000001             - *  INPUT FILENAME = D APGE2M
000002             - *****************************************************************************
000003             - *                                                                           *
000004             - *   U S  ARMY ABERDEEN PROVING GROUNDS, ABERDEEN, MARYLAND                  *
000005             - *   MILITARY FAMILY HOUSING STUDY                                           *
000006             - *   EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT                        *
000007             - *                                                                           *
000008             - *****************************************************************************
000009             -
000010             -
000011    000001   - THE TITLES ARE 'ABERDEEN PROVING GROUNDS, MD ' 'MILITARY FAMILY HOUSING STUDY' &
000012    000001   - 'EDGEWOOD ARSENAL--WASHINGTON COURT AND LEE COURT' &
000013    000001   - 'PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS' &
000014    000001   - 'MAY 1982'
000015             -
000016    000002   - ORGANIZATION &
000017    000002   - 'LOGISTICS DIRECTORATE, HOUSING DIVISION, ABERDEEN PROVING GROUNDS, MD'
000018             -
000019    000003   - PROJECT &
000020    000003   - 'ECONOMIC ANALYSIS OF FAMILY HOUSING ALTERNATIVES'
000021    000004   - OBJECTIVE &
000022    000004   - 'PROVIDE 392 ADEQUATE FAMILY HOUSING UNITS FOR ENLISTED PERSONNEL'
000023             -
000024    000005   - DATE 'MAY 1982'
000025             -
000026             -
000027    000006   - BEGIN DATA
000028             -
000029    000007   - THE PERIOD IS 25
000030    000008   - BASE-YEAR IS 1983
000031    000009   - START-YEAR IS 1983
000032    000010   - RATE 10 0
000033    000011   - EXPENSE-ITEM-1 'CONSTR COST 30 YR LIFE EA' 6836000 11720000 11824000 4958000 &
000034    000011   - 21*0
000035    000012   - EXPENSE-ITEM-2 'REHAB COST 30 YR LIFE EA' 3280000 5069000 3408000 &
000036    000012   - 3706000 1234000 20*0
000037    000013   - EXPENSE-ITEM-3 'LAND AQUISITION EA' 25*0
000038    000014   - EXPENSE-ITEM-4 'PRPTY DSPSL EXSTG UNITS EA' 0 -1960000 23*0
000039    000015   - EXPENSE-ITEM-5 'LEASE RENTAL  EA' 25*1543000
000040    000016   - EXPENSE-ITEM-6 'ALLOWANCES  (MCA)  EA' 25*0
000041    000017   - EXPENSE-ITEM-7 'ALLOWANCES 30 YR REHAB EA' 547000 836000 533000 618000 206000 &
000042    000017   - 20*0
000043    000018   - EXPENSE-ITEM-8 'ALLOWANCES  (LEASE)  EA' 25*0
000044    000019   - EXPENSE-ITEM-9 'ALLOWANCES  (ECONOMY)  EA' 25*2088000
000045    000020   - EXPENSE-ITEM-10 'MNT AND RPR MCA EA' 0 96000 261000 428000 21*498000
000046    000021   - EXPENSE-ITEM-11 'MNT AND RPR (LEASE)  EA' 25*51000
000047    000022   - EXPENSE-ITEM-12 'MNT AND RPR 30 YR REHAB EA' 0 66000 263000 412000 &
000048    000022   - 528000 20*586000
000049    000023   - EXPENSE-ITEM-13 'UTILITIES MCA EA' 739000 717000 680000 643000 21*628000
000050    000024   - EXPENSE-ITEM-14 'UTILITIES 30 YR REHAB EA' 545000 443000 550000 520000 &
```


Exhibit 8

```
COMMAND
NUMBER              COMMAND
------   -----------------------------------------------------------------------------
000024 - 666000 20*739000
000025 - EXPENSE-ITEM-15 'UTILITIES: (LEASE): EA' 25*628000
000026 - EXPENSE-ITEM-16 'SERVICES: (LEASE): EA' 25*101000
000027 - EXPENSE-ITEM-17 'SERVICES MCA EA' 25*101000
000028 - EXPENSE-ITEM-18 'SERVICES 30 YR REHAB EA' 75000 61000 75000 71000 &
000028 - 91000 20*101000
000029 - EXPENSE-ITEM-19 'CONTR ADMIN (LEASE): EA' 25*44000
000030 - EXPENSE-ITEM-20 'ADMIN (MCA AND REHAB) EA' 25*890000
000031 - EXPENSE-ITEM-21 'ADMIN (LSE AND ECON): EA' 25*801000
       -
       -
       -
000032 - INFLATION-INDEX IS 'NO INFLATION' 25*0.0
       -
000033 - INFLATION-INDEX IS 'OASD(C) O&M (4-20-82)' C.0 0.0510 0.0473 0.0453 .0444 &
000033 - 20*0 045
       -
000034 - INFLATION-INDEX IS 'OASD(C) MILCON (4-20-82)' 0 0 0.0510 0.0473 0.0453 .0444 &
000034 - 20*0 045
       -
000035 - INFLATION-INDEX IS 'OASD(C) MILPERS (4-20-82)' 0.0 0.051 0.0473 0.0453 0.0444 &
000035 - 20*0 045
       -
       -
000036 - RESIDUAL 'ZERO RESIDUAL'  25*0 0
       -
000037 - RESIDUAL 'MCA ECONOMIC LIFE = 30 YEARS' 3*1 0 .994 .987 .98 .972 .963 .953 &
000037 -  .942 .93 .917 .903 .887 .87 .851 .83 .807 .782 .754 .723 .689 .652 .611 .566
       -
000038 - RESIDUAL 'REHAB ECONOMIC LIFE = 30 YEARS' 3*1 0 .994 .987 .98 .972 .963 .953 &
000038 -  .942 .93 .917 .903 .887 .87 .851 .83 .807 .782 .754 .723 .689 .652 .611 .566
000039 - END DATA
       -
       -
       -
       -
000040 - BEGIN COMPUTATIONS
000041 - ITERATION NAME IS '30 YR MCA WITH RESID'
000042 - ITERATION TITLES ARE '30 YR MCA WITH RESID'
000043 - ECONOMIC-LIFE IS '30 YEARS'
000044 - SELECTED EXPENSE-ITEMS ARE 1 3 4 6 10 13 17 20
000045 - SELECT DISCOUNT-FACTOR 8*2
000046 - SELECT PRICE-INDEX 3 3 3 4 3*2 4
000047 - SELECT RESIDUAL NAME 2
000048 - SELECT RESIDUAL DISCOUNT 3
000049 - SELECT RESIDUAL PRICE 3
000050 - END COMPUTATIONS
       -
000051 - BEGIN COMPUTATIONS
000052 - ITERATION NAME IS '30 YR REHAB WITH RESID'
```

Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER             COMMAND
------    ------  ------------------------------------------------------------------
000101    000053 - ITERATION TITLES ARE '30 YEAR REHAB WITH RESID'
000102    000054 - ECONOMIC-LIFE IS '30 YEARS'
000103    000055 - SELECTED EXPENSE-ITEMS ARE 2 3 7 12 14 18 20
000104    000056 - SELECT DISCOU r 7*2
000105    000057 - SELECT PRICE-INDEX 2*3 4 3*2 4
000106    000058 - SELECT RESIDUAL NAME 3
000107    000059 - SELECT RESIDUAL DISCOUNT 3
000108    000060 - SELECT RESIDUAL PRICE 3
000109    000061 - END COMPUTATIONS
000110           -
000111           -
000112    000062 - BEGIN COMPUTATIONS
000113    000063 - ITERATION NAME IS 'LEASE RENTAL'
000114    000064 - ITERATION TITLES ARE 'LEASE RENTAL'
000115    000065 - ECONOMIC-LIFE IS 'NOT APPLICABLE'
000116    000066 - SELECTED EXPENSE-ITEMS ARE 4 5 8 11 15 16 19 21
000117    000067 - SELECT DISCOUNT 8*2
000118    000068 - SELECT PRICE-INDEX 3 3 4 3*2 2*4
000119    000069 - END COMPUTATIONS
000120           -
000121    000070 - BEGIN COMPUTATIONS
000122    000071 - ITERATION NAME IS 'ECONOMY HOUSING'
000123    000072 - ITERATION TITLES ARE 'ECONOMY HOUSING'
000124    000073 - ECONOMIC-LIFE IS 'NOT APPLICABLE'
000125    000074 - SELECTED EXPENSE-ITEMS ARE 4 9 21
000126    000075 - SELECT DISCOUNT 3*2
000127    000076 - SELECT PRICE-INDEX 3 2*4
000128    000077 - END COMPUTATIONS
000129           -
000130           -
000131           -
000132    000078 - BEGIN OUTPUT
000133    000079 - BY-YEAR REPORT
000134    000080 - SUMMARY REPORT
000135    000081 - END OUTPUT
000136           -
000137           -
000138           -
000139    000082 - BEGIN GRAPHICS
000140    000083 - PLOT TITLES ARE 'GRAPHICAL DISPLAY OF RESULTS' &
000141    000083 - 'NET PRESENT VALUE, FY 83 THROUGH INDICATED FISCAL YEAR'
000142    000084 - PLOT ITERATIONS ARE 1 2 3 4
000143    000085 - XLABEL IS 'FISCAL YEAR'
000144    000086 - YLABEL IS 'NET CUMULATIVE PRESENT VALUE'
000145    000087 - LEGEND 'MCA,30 YR,W/RESIDUAL'
000146    000088 - LEGEND 'REHAB,30 YR,W/RESIDUAL'
000147    000089 - LEGEND 'LEASE RENTAL'
000148    000090 - LEGEND 'ECONOMY HOUSING'
000149    000091 - END GRAPHICS
000150           -
```


Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER            COMMAND
------    ------  ----------------------------------------------------------------------------
000151          -
000152          -
000153    000092 - BEGIN RANKING SENSITIVITY
000154    000093 - RUN TITLE '% CHANGE IN CONSTRUCTION COSTS (BOTH MCA AND REHAB) FOR MCA TO BE&
000155    000093 - LEAST COST'
000156    000094 - SELECT ITERATIONS 1 2 3 4
000157    000095 - CHANGE 1 2
000158    000096 - LIMIT 500
000159    000097 - TIME 25
000160    000098 - RANK 1
000161    000099 - END RANKING SENSITIVITY
000162          -
000163          -
000164    000100 - BEGIN RANKING SENSITIVITY
000165    000101 - RUN TITLE '% CHANGE IN CONSTRUCTION COSTS (BOTH MCA AND REHAB) FOR REHAB TO BE&
000166    000101 - LEAST COST'
000167    000102 - SELECT ITERATIONS 1 2 3 4
000168    000103 - CHANGE 1 2
000169    000104 - LIMIT 500
000170    000105 - TIME 25
000171    000106 - RANK 2
000172    000107 - END RANKING SENSITIVITY
000173          -
000174          -
000175          -
000176          -
000177    000108 - BEGIN RANKING SENSITIVITY
000178    000109 - RUN TITLE '% CHANGE IN CONSTRUCTION COSTS (BOTH MCA AND REHAB) FOR LEASE&
000179    000109 - TO BE LEAST COST'
000180    000110 - SELECT ITERATIONS 1 2 3 4
000181    000111 - CHANGE 1 2
000182    000112 - LIMIT 500
000183    000113 - TIME 25
000184    000114 - RANK 3
000185    000115 - END RANKING SENSITIVITY
000186          -
000187          -
000188          -
000189          -
000190          -
000191    000116 - BEGIN RANKING SENSITIVIT'
000192    000117 - RUN TITLE '% CHANGE IN LEASE RENT FOR MCA TO BE LEAST COST'
000193    000118 - SELECT ITERATIONS 1 2 3 4
000194    000119 - CHANGE 5
000195    000120 - LIMIT 500
000196    000121 - TIME 25
000197    000122 - RANK 1
000198    000123 - END RANKING SENSITIVITY
000199          -
000200          -
```


Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER             COMMAND
------    ------   -----------------------------------------------------------------------------
000201    000124 - BEGIN RANKING SENSITIVITY
000202    000125 - RUN TITLE '% CHANGE IN LEASE RENT FOR REHAB TO LEAST COST'
000203    000126 - SELECT ITERATIONS 1 2 3 4
000204    000127 - CHANGE 5
000205    000128 - LIMIT 500
000206    000129 - TIME 25
000207    000130 - RANK 2
000208    000131 - END RANKING SENSITIVITY
000209           -
000210           -
000211    000132 - BEGIN RANKING SENSITIVITY
000212    000133 - RUN TITLE '% CHANGE IN LEASE RENT FOR LEASE ALTERNATIVE TO BE LEAST COST'
000213    000134 - SELECT ITERATIONS 1 2 3 4
000214    000135 - CHANGE 5
000215    000136 - LIMIT 500
000216    000137 - TIME 25
000217    000138 - RANK 3
000218    000139 - END RANKING SENSITIVITY
000219           -
000220           -
000221    000140 - BEGIN RANKING SENSITIVITY
000222    000141 - RUN TITLE '% CHANGE IN ALLOWANCES FOR MCA TO BE LEAST COST'
000223    000142 - SELECT ITERATIONS 1 2 3 4
000224    000143 - CHANGE 6 7 8 9
000225    000144 - LIMIT 500
000226    000145 - TIME 25
000227    000146 - RANK 1
000228    000147 - END RANKING SENSITIVITY
000229           -
000230           -
000231    000148 - BEGIN RANKING SENSITIVITY
000232    000149 - RUN TITLE '% CHANGE IN ALLOWANCES FOR REHAB TO BE LEAST COST'
000233    000150 - SELECT ITERATIONS 1 2 3 4
000234    000151 - CHANGE 6 7 8 9
000235    000152 - LIMIT 500
000236    000153 - TIME 25
000237    000154 - RANK 2
000238    000155 - END RANKING SENSITIVITY
000239           -
000240           -
000241    000156 - BEGIN RANKING SENSITIVITY
000242    000157 - RUN TITLE '% CHANGE IN ALLOWANCES FOR LEASE TO BE LEAST COST'
000243    000158 - SELECT ITERATIONS 1 2 3 4
000244    000159 - CHANGE 6 7 8 9
000245    000160 - LIMIT 500
000246    000161 - TIME 25
000247    000162 - RANK 3
000248    000163 - END RANKING SENSITIVITY
000249           -
000250           -
```


Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER              COMMAND
------    ------   -------------------------------------------------------------------------------
000251    000164 - BEGIN RANKING SENSITIVITY
000252    000165 - RUN TITLE '% CHANGE IN MAINTENANCE AND REPAIR FOR MCA TO BE LEAST COST'
000253    000166 - SELECT ITERATIONS 1 2 3 4
000254    000167 - CHANGE 10 11 12
000255    000168 - LIMIT 500
000256    000169 - TIME 25
000257    000170 - RANK 1
000258    000171 - END RANKING SENSITIVITY
000259           -
000260           -
000261    000172 - BEGIN RANKING SENSITIVITY
000262    000173 - RUN TITLE '% CHANGE IN MAINTENANCE AND REPAIR FOR REHAB TO BE LEAST COST'
000263    000174 - SELECT ITERATIONS 1 2 3 4
000264    000175 - CHANGE 10 11 12
000265    000176 - LIMIT 500
000266    000177 - TIME 25
000267    000178 - RANK 2
000268    000179 - END RANKING SENSITIVITY
000269           -
000270           -
000271    000180 - BEGIN RANKING SENSITIVITY
000272    000181 - RUN TITLE '% CHANGE IN MAINTENANCE AND REPAIR FOR LEASE TO BE LEAST COST'
000273    000182 - SELECT ITERATIONS 1 2 3 4
000274    000183 - CHANGE 10 11 12
000275    000184 - LIMIT 500
000276    000185 - TIME 25
000277    000186 - RANK 3
000278    000187 - END RANKING SENSITIVITY
000279           -
000280           -
000281           -
000282           -
000283           -
000284    000188 - BEGIN RANKING SENSITIVITY
000285    000189 - RUN TITLE '% CHANGE IN UTILITIES FOR MCA TO BE LEAST COST'
000286    000190 - SELECT ITERATIONS 1 2 3 4
000287    000191 - CHANGE 13 14 15
000288    000192 - LIMIT 500
000289    000193 - TIME 25
000290    000194 - RANK 1
000291    000195 - END RANKING SENSITIVITY
000292           -
000293           -
000294    000196 - BEGIN RANKING SENSITIVITY
000295    000197 - RUN TITLE '% CHANGE IN UTILITIES FOR REHAB TO BE LEAST COST'
000296    000198 - SELECT ITERATIONS 1 2 3 4
000297    000199 - CHANGE 13 14 15
000298    000200 - LIMIT 500
000299    000201 - TIME 25
000300    000202 - RANK 2
```


Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER           COMMAND
------    ------   ---------------------------------------------------------------------
000301    000203 - END RANKING SENSITIVITY
000302           -
000303           -
000304    000204 - BEGIN RANKING SENSITIVITY
000305    000205 - RUN TITLE '% CHANGE IN UTILITIES FOR LEASE TO BE LEAST COST'
000306    000206 - SELECT ITERATIONS 1 2 3 4
000307    000207 - CHANGE 13 14 15
000308    000208 - LIMIT 500
000309    000209 - TIME 25
000310    000210 - RANK 3
000311    000211 - END RANKING SENSITIVITY
000312           -
000313           -
000314           -
000315           -
000316    000212 - BEGIN RANKING SENSITIVITY
000317    000213 - RUN TITLE '% CHANGE IN SERVICES FOR MCA TO BE LEAST COST'
000318    000214 - SELECT ITERATIONS 1 2 3 4
000319    000215 - CHANGE 16 17 18
000320    000216 - LIMIT 500
000321    000217 - TIME 25
000322    000218 - RANK 1
000323    000219 - END RANKING SENSITIVITY
000324           -
000325           -
000326    000220 - BEGIN RANKING SENSITIVITY
000327    000221 - RUN TITLE '% CHANGE IN SERVICES FOR REHAB TO LEAST COST'
000328    000222 - SELECT ITERATIONS 1 2 3 4
000329    000223 - CHANGE 16 17 18
000330    000224 - LIMIT 500
000331    000225 - TIME 25
000332    000226 - RANK 2
000333    000227 - END RANKING SENSITIVITY
000334           -
000335           -
000336           -
000337           -
000338           -
000339    000228 - BEGIN RANKING SENSITIVITY
000340    000229 - RUN TITLE '% CHANGE IN SERVICES FOR LEASE TO LEAST COST'
000341    000230 - SELECT ITERATIONS 1 2 3 4
000342    000231 - CHANGE 16 17 18
000343    000232 - LIMIT 500
000344    000233 - TIME 25
000345    000234 - RANK 3
000346    000235 - END RANKING SENSITIVITY
000347           -
000348           -
000349    000236 - BEGIN RANKING SENSITIVITY
000350    000237 - RUN TITLE '% CHANGE IN CONTRACT ADMIN FOR MCA TO BE LEAST COST'
```


Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER              COMMAND
------    ------    ---------------------------------------------------------------------
000351    000238 - SELECT ITERATIONS 1 2 3 4
000352    000239 - CHANGE 19
000353    000240 - LIMIT 500
000354    000241 - TIME 25
000355    000242 - RANK 1
000356    000243 - END RANKING SENSITIVITY
000357           -
000358           -
000359    000244 - BEGIN RANKING SENSITIVITY
000360    000245 - RUN TITLE '% CHANGE IN CONTRACT ADMIN FOR REHAB TO BE LEAST COST'
000361    000246 - SELECT ITERATIONS 1 2 3 4
000362    000247 - CHANGE 19
000363    000248 - LIMIT 500
000364    000249 - TIME 25
000365    000250 - RANK 2
000366    000251 - END RANKING SENSITIVITY
000367           -
000368           -
000369    000252 - BEGIN RANKING SENSITIVITY
000370    000253 - RUN TITLE '% CHANGE IN CONTRACT ADMIN FOR LEASE TO BE LEAST COST'
000371    000254 - SELECT ITERATIONS 1 2 3 4
000372    000255 - CHANGE 19
000373    000256 - LIMIT 500
000374    000257 - TIME 25
000375    000258 - RANK 3
000376    000259 - END RANKING SENSITIVITY
000377           -
000378           -
000379    000260 - BEGIN RANKING SENSITIVITY
000380    000261 - RUN TITLE '% CHANGE IN ADMIN FOR MCA TO BE LEAST COST'
000381    000262 - SELECT ITERATIONS 1 2 3 4
000382    000263 - CHANGE 20 21
000383    000264 - LIMIT 500
000384    000265 - TIME 25
000385    000266 - RANK 1
000386    000267 - END RANKING SENSITIVITY
000387           -
000388           -
000389    000268 - BEGIN RANKING SENSITIVITY
000390    000269 - RUN TITLE '% CHANGE IN ADMIN FOR REHAB TO BE LEAST COST'
000391    000270 - SELECT ITERATIONS 1 2 3 4
000392    000271 - CHANGE 20 21
000393    000272 - LIMIT 500
000394    000273 - TIME 25
000395    000274 - RANK 2
000396    000275 - END RANKING SENSITIVITY
000397           -
000398           -
000399           -
000400           -
```


Exhibit B

```
SEQUENCE  COMMAND
NUMBER    NUMBER              COMMAND
------    ------   ------------------------------------------------------------
000401           -
000402    000276 - BEGIN RANKING SENSITIVITY
000403    000277 - RUN TITLE '% CHANGE IN REHAB CONSTRUCTION COSTS FOR MCA&
000404    000277 - TO BE LESS COSTLY THAN REHAB'
000405    000278 - SELECT ITERATIONS 1 2
000406    000279 - CHANGE 2
000407    000280 - LIMIT 500
000408    000281 - TIME 25
000409    000282 - RANK 1
000410    000283 - END RANKING SENSITIVITY
000411           -
000412    000284 - BEGIN RANKING SENSITIVITY
000413    000285 - RUN TITLE '% CHANGE IN REHAB CONSTRUCTION COSTS FOR &
000414    000285 - REHAB TO BE LESS COSTLY THAN LEASE'
000415    000286 - SELECT ITERATIONS 2 3
000416    000287 - CHANGE 2
000417    000288 - LIMIT 500
000418    000289 - TIME 25
000419    000290 - RANK 2
000420    000291 - END RANKING SENSITIVITY
000421           -
000422           -
000423    000292 - BEGIN RANKING SENSITIVITY
000424    000293 - RUN TITLE '% CHANGE IN REHAB CONSTRUCTION COSTS FOR &
000425    000293 - REHAB TO BE LESS COSTLY THAN ECONOMY HOUSING'
000426    000294 - SELECT ITERATIONS 2 4
000427    000295 - CHANGE 2
000428    000296 - LIMIT 500
000429    000297 - TIME 25
000430    000298 - RANK 2
000431    000299 - END RANKING SENSITIVITY
000432           -
000433           -
000434    000300 - BEGIN RANKING SENSITIVITY
000435    000301 - RUN TITLE '% CHANGE IN MCA CONSTRUCTION COSTS FOR MCA&
000436    000301 - TO BE LESS COSTLY THAN REHAB'
000437    000302 - SELECT ITERATIONS 1 2
000438    000303 - CHANGE 1
000439    000304 - LIMIT 500
000440    000305 - TIME 25
000441    000306 - RANK 1
000442    000307 - END RANKING SENSITIVITY
000443           -
000444           -
000445           -
000446    000308 - BEGIN RANKING SENSITIVITY
000447    000309 - RUN TITLE '% CHANGE IN MCA CONSTRUCTION COSTS FOR MCA&
000448    000309 - TO BE LESS COSTLY THAN LEASE'
000449    000310 - SELECT ITERATIONS 1 3
000450    000311 - CHANGE 1
```

```
SEQUENCE  COMMAND
NUMBER    NUMBER            COMMAND
------    ------    -------------------------------------------------------------
000451    000312 - LIMIT 500
000452    000313 - TIME 25
000453    000314 - RANK 1
000454    000315 - END RANKING SENSITIVITY
000455           -
000456           -
000457           -
000458    000316 - BEGIN RANKING SENSITIVITY
000459    000317 - RUN TITLE '% CHANGE IN MCA CONSTRUCTION COSTS FOR MCA&
000460    000317 - TO BE LESS COSTLY THAN ECONOMY HOUSING'
000461    000318 - SELECT ITERATIONS 1 4
000462    000319 - CHANGE 1
000463    000320 - LIMIT 500
000464    000321 - TIME 25
000465    000322 - RANK 1
000466    000323 - END RANKING SENSITIVITY
000467           -
000468           -
000469           -
000470    000324 - BEGIN RANKING SENSITIVITY
000471    000325 - RUN TITLE '% CHANGE IN MNT AND RPR COSTS FOR MCA UNITS&
000472    000325 - FOR MCA TO BE LESS COSTLY THAN REHAB'
000473    000326 - SELECT ITERATIONS 1 2
000474    000327 - CHANGE 10
000475    000328 - LIMIT 500
000476    000329 - TIME 25
000477    000330 - RANK 1
000478    000331 - END RANKING SENSITIVITY
000479           -
000480           -
000481    000332 - BEGIN RANKING SENSITIVITY
000482    000333 - RUN TITLE '% CHANGE IN MNT AND RPR COSTS FOR MCA UNITS&
000483    000333 - FOR MCA TO BE LESS COSTLY THAN LEASE'
000484    000334 - SELECT ITERATIONS 1 3
000485    000335 - CHANGE 10
000486    000336 - LIMIT 500
000487    000337 - TIME 25
000488    000338 - RANK 1
000489    000339 - END RANKING SENSITIVITY
000490           -
000491           -
000492    000340 - BEGIN RANKING SENSITIVITY
000493    000341 - RUN TITLE '% CHANGE IN MNT AND RPR COSTS FOR MCA UNITS&
000494    000341 - FOR MCA TO BE LESS COSTLY THAN ECONOMY HOUSING'
000495    000342 - SELECT ITERATIONS 1 4
000496    000343 - CHANGE 10
000497    000344 - LIMIT 500
000498    000345 - TIME 25
000499    000346 - RANK 1
000500    000347 - END RANKING SENSITIVITY
```


Exhibit 8

```
SEQUENCE  COMMAND
NUMBER    NUMBER           COMMAND
------    ------   ------------------------------------------------------------------------------
000501           -
000502           -
000503    000348 - BEGIN RANKING SENSITIVITY
000504    000349 - RUN TITLE '% CHANGE IN UTILITIES COSTS FOR MCA UNITS%
000505    000349 - FOR MCA TO BE LESS COSTLY THAN REHAB'
000506    000350 - SELECT ITERATIONS 1 2
000507    000351 - CHANGE 13
000508    000352 - LIMIT 500
000509    000353 - TIME 25
000510    000354 - RANK 1
000511    000355 - END RANKING SENSITIVITY
000512           -
000513           -
000514    000356 - BEGIN RANKING SENSITIVITY
000515    000357 - RUN TITLE '% CHANGE IN UTILITIES COSTS FOR MCA AND LEASE&
000516    000357 - FOR MCA TO BE LESS COSTLY THAN LEASE'
000517    000358 - SELECT ITERATIONS 1 3
000518    000359 - CHANGE 13 15
000519    000360 - LIMIT 500
000520    000361 - TIME 25
000521    000362 - RANK 1
000522    000363 - END RANKING SENSITIVITY
000523           -
000524           -
000525           -
000526           -
000527    000364 - BEGIN RANKING SENSITIVITY
000528    000365 - RUN TITLE '% CHANGE IN UTILITIES COSTS FOR MCA UNITS%
000529    000365 - FOR MCA TO BE LESS COSTLY THAN ECONOMY HOUSING'
000530    000366 - SELECT ITERATIONS 1 4
000531    000367 - CHANGE 13
000532    000368 - LIMIT 500
000533    000369 - TIME 25
000534    000370 - RANK 1
000535    000371 - END RANKING SENSITIVITY
000536           -
000537           -
000538           -
000539    000372 - BEGIN RANKING SENSITIVITY
000540    000373 - RUN TITLE '% CHANGE IN MNT AND RPR AND UTILITIES%
000541    000373 - FOR MCA UNITS FOR MCA TO BE LESS COSTLY THAN REHAB'
000542    000374 - SELECT ITERATIONS 1 2
000543    000375 - CHANGE 10 13
000544    000376 - LIMIT 500
000545    000377 - TIME 25
000546    000378 - RANK 1
000547    000379 - END RANKING SENSITIVITY
000548           -
000549           -
000550    000380 - BEGIN RANKING SENSITIVITY
```

```
SEQUENCE  COMMAND
NUMBER    NUMBER              COMMAND
------    ------   ------------------------------------------------------------------------
000551    000381 - RUN TITLE '% CHANGE IN MNT AND RPR AND UTILITIES FOR MCA&
000552    000381 - UNITS FOR MCA TO BE LESS COSTLY THAN LEASE'
000553    000382 - SELECT ITERATIONS 1 3
000554    000383 - CHANGE 10 13 15
000555    000384 - LIMIT 500
000556    000385 - TIME 25
000557    000386 - RANK 1
000558    000387 - END RANKING SENSITIVITY
000559           -
000560           -
000561    000388 - BEGIN RANKING SENSITIVITY
000562    000389 - RUN TITLE '% CHANGE IN MNT AND RPR AND UTILITIES FOR MCA&
000563    000389 - UNITS FOR MCA TO BE LESS COSTLY THAN ECONOMY HSNG'
000564    000390 - SELECT ITERATIONS 1 4
000565    000391 - CHANGE 10 13
000566    000392 - LIMIT 500
000567    000393 - TIME 25
000568    000394 - RANK 1
000569    000395 - END RANKING SENSITIVITY
000570           -
000571           -
000572    000396 - STOP RUN
```


Exhibit 8

DAMAGE

A COMPUTER PROGRAM FOR CALCULATION OF AVERAGE ANNUAL FLOOD DAMAGES FOR A GIVEN CONDITION, OR FOR A WITHOUT-PROJECT AND A WITH-PROJECT CONDITION WITH RESULTING BENEFITS

William T. Hunt, Regional Economist
Linda C. Y. Chock, Computer Scientist
Michael S. Fenton, Computer Scientist

Pacific Ocean Division
Corps of Engineers
October 1982

Table of Contents

DAMAGE

Summary

Damage computes average annual damages either for a given hydrologically defined condition, or for two separately defined conditions. When two conditions are specified, the program treats the first condition as the without-project condition and the second condition as the with-project condition, and computes the difference as inundation damage reduction benefits attributable to the project. The program is oriented primarily to urban area analysis and does not readily lend itself to agricultural flood damage evaluation.

Required Input

Water surface profile data--Exhibits 1 and 2 show coding sheet format for organizing data, and a sample water surface profile data file.

Damageable property data--Exhibits 3 and 4 show coding sheet format and a sample property inventory data file.

Standardized depth-damage data--Exhibit 5 shows a sample depth-damage curve data file, annotated with appropriate coding information. Exhibits 6 through 8 show these curves graphically.

Outline of Process

The program calculates damage resulting from each flood flow contained in the water surface profile data.

The program computes the area under the damage - exceedence probability curve for the given condition using the trapezoidal integration method (i.e., assuming straight line segments between computed points), resulting in an average annual expected value amount. Exhibit 9 is a graphical depiction of this process.

Damage computations are done by computing flooding over the first floor of each structure/damage unit (the user may specify more than one damage unit per strucure, as in the case of several commercial establishments in the same structure) by comparing the first floor elevation to the flood elevation for the given flow at the stream station reference location at which the structure is located. Once the level of flooding is calculated, damages to all structures and to residential contents are computed using standardized depth-damage curve input data that relate depth of flooding in the structure to damage (expressed as a fraction of total market value). Damages to contents of non-residential units are computed with user-specified depth-damage data specific to the individual damage unit (usually obtained by survey interview). In the damage computations, the program interpolates/extrapolates, subject to a built-in constraint limiting non-residential content damage to 80% of total content market value, unless otherwise specified by the user in the property inventory input data.

There are damage curves for structures, and for contents, by building type. There are curves for high velocity and low velocity flow zones. Zones and building types are specified by the user. Exhibit 10 shows a sample interactive session for a Damage computer program run.

Program Output

Exhibit 11 shows portions of output from the sample run. In addition to the output shown in the sample the program generates input data for doing graphics with the graphics program CEEGX.

Limitations

The primary limitations of the current version of Damage are related to the fact that the program has been developed with typical flood plain characteristics found within POD's jurisdiction in mind. The program tends to be oriented to single story flooding, although basements can be included with certain adjustments. Also, the program calculates content value for residential units using structure value as input with a built-in calculation based

on a POD study for a residential flood plain in Hawaii. Finally, there are limitations associated with the two-dimensional nature of the water surface profile and property location data. While the program does not automatically handle intra-floodplain peculiarities such as ponding areas, swales, and localized flow diversions, the informed user can make separate Damage runs for these conditions if sufficient information is available.

Further Information

The conceptual framework for this program grew out of the use in POD of a program called Urbdam, introduced to use in POD by Dr. James Dexter, who formerly used Urbdam in flood control evaluation studies in St. Louis District, Corps of Engineers. The conceptual design for Damage was formulated by POD Economist William Hunt. The program was written by Linda Blake and Michael Fenton, POD ADP Center, Engineering Systems Analysis Branch. It is currently written in Fortran and is used on POD's Harris 125 computer. For further information on Damage, contact POD Planning Branch, Engineering Division (William Hunt 808-438-2259), or POD ADP Center, Engineering Systems Analysis Branch (Michael Fenton 808-438-9500).

Sample Water Surface Profile Data File Coding Sheet

Preferred order of entries by type is as shown below

Col. 1	Col. 2	Cols. 3–8	Cols. 9–16	Cols. 17–20	Cols. 21–24	Cols. 25–80
T		Three T entries are required, and may contain any header, or title information you wish to enter				
T						
T						
S		2	Number of stations for which water surface elevation data are entered. In this case, there are only two staions.			
C		12	Number of events, or Q's, or floods, for which elevation data is entered. S and C data end in column 8.			
Y			2		5	Ending in columns 16, 24, ... (every 8) will be entered the return period, in ascending order, of
Y	1			20		the flows for which data are entered. Continuation lines must have something other than a blank in
D		0	3		7	column 2, and the return period entries end in columns 20, 28, ... (every 8).
D	1			12		
D		6	8		11	
D	1			16		For each station number there will be entered an elevation for every flood, ending in the same
						column that the return period entry ends in in the Y entry. Continuation D entry data is
						handled in the same manner as is continuation Y entry data. For continuation D entry data, sta-
						tion number entry is not to be entered. The station number is entered on the first line
						of a given D entry, ending in column 8.

ENG FORM MAY 68 2900 (Local reproduction of this form is authorized after desired information is filled-in.) 80 COLUMN KEY PUNCH TRANSCRIPT LAYOUT SHEET SHEET OF SHEETS

Exhibit

```
T DISASTER STREAM FLOOD DAMAGE REDUCTION STUDY
T WATER SURFACE PROFILE DATA  FILE:  WSPTEST
T WITHOUT PROJECT
C      8
Y              1.5          2          5         10         50        100        300        500
S    120
*
*   STA NO    1.5 YR   2 YR       5 YR     10 YR      50 YR    100 YR    300 YR    500 YR
*                                                                                   (SPF)
*
D       0          0          3          3          3        3.1        3.7        4.7        5.7
D     220          0        3.1        3.3        3.6        5.1        5.9        6.7        7.4
D     430          0        3.2        3.5        3.9        5.5        6.2        6.9        7.6
D     650          0        3.6        5.2          6        6.8        7.2        7.7        8.2
D     900          0          5        6.3        6.6        7.6        8.3        8.8        9.3
D    1150          0        5.3        6.7        7.3        9.0        9.4        9.9       10.3
D    1450          0        5.6        7.2        7.9        9.4        9.8       10.4       10.9
D    1730          0        6.1        7.3        8.0        9.5        9.9       10.5       11.1
D    2000          0        6.3        7.4        8.1        9.6       10.0       10.6       11.2
D    2300          0        7.2        7.9        8.3        9.7       10.1       10.7       11.3
D    2630          0        7.9        8.6        8.9        9.9       10.3       10.9       11.5
D    2900          0        8.0        8.7        9.0       10.0       10.4       11.0       11.6
D    2950          0        7.9        8.8        9.2       10.2       10.5       11.0       11.6
D    3000          0        8.0        9.1        9.5       10.5       10.8       11.3       11.8
D    3050          0        8.6        9.6       10.1       11.0       11.3       11.7       12.0
D    3100          0        8.9        9.9       10.5       11.3       11.7       12.2       12.6
D    3260          0        9.2       11.0       11.4       12.1       12.4       12.9       13.3
D    3350          0       10.6       11.2       11.6       12.6       15.4       16.2       16.9
D    3419          0       10.5       11.0       12.7       17.1       17.8       18.4       18.9
D    3420          0       10.5       11.0       12.8       18.0       18.8       19.6       20.4
D    3480          0       10.6       12.8       12.9       20.3       21.0       21.8       22.6
D    3481          0       10.6       13.3       18.0       20.2       20.8       21.6       22.4
D    3535          0       10.2       12.8       17.9       20.1       20.8       21.6       22.4
D    3700          0       13.2       15.7       19.3       21.2       21.8       22.6       23.2
D    3900          0       16.0       18.4       21.1       24.3       25.2       26.2       27.2
D    4070          0       19.0       22.3       23.8       27.0       27.9       28.7       29.4
D    4150          0       22.5       25.8       29.4       30.4       30.9       31.4       31.9
D    4151          0       22.5       25.8       29.4       30.4       30.9       31.4       31.9
D    4199          0       24.1       31.7       30.5       31.8       32.3       33.0       33.7
D    4200          0       20.7       27.2       28.1       29.5         30       30.8       31.6
D    4300          0       26.4       31.7       31.0       31.9       32.4       33.2       33.9
D    4360          0       31.3       32.3       32.7       33.6       34.0       34.5       35.0
D    4520          0       32.8       33.7       34.2       35.8       37.2       38.3       39.4
D    4640          0       33.2       34.5       35.6       38.3       39.2       39.8       40.3
D    4732          0       33.2       34.8       36.1       39.0       40.1       41.9       43.7
D    4768          0       33.3       36.1       44.2       47.1       48.1       48.7       49.9
D    4850          0       35.1       36.9       44.0       46.9       47.9       49.1       50.3
D    4985          0       42.0       45.0       46.9       51.5       53.4       55.8       58.3
D    5215          0       46.0       49.3       51.6       56.0       57.6       59.4       61.1
D    5360          0       58.4       60.7       62.2       66.1       67.9       70.6       73.3
D    5385          0       68.4       70.7       72.3       76.1       77.9       80.7       83.4
D    5420          0       71.0       74.0       76.2       81.4       83.9       87.1       90.4
D    5450          0       70.8       78.3       78.9       79.8       82.9       86.4       89.9
D    5510          0       71.1       78.5       79.3       81.7       84.6       88.0       91.5
D    5795          0       76.4       78.6       80.4       83.8       85.2       87.8       90.6
```


Exhibit 2

D	6065	0	83.9	85.9	87.3	92.2	92.4	93.8	95.2
D	6300	0	91.5	93.7	95.0	97.3	98.2	99.9	102.5
D	6500	0	95.8	97.5	98.6	101.1	102.1	102.5	102.9
D	6760	0	100.0	101.0	101.6	103.2	105.1	105.1	105.1
D	6950	0	103.6	104.9	105.8	107.1	107.1	107.3	107.4
D	7055	0	106.0	107.6	108.7	109.0	109.7	110.7	111.8
D	7215	0	109.5	110.7	111.5	113.8	114.8	116.3	117.8
D	7390	0	114.5	116.1	117.2	119.4	120.5	121.6	123.1
D	7580	0	119.2	120.5	121.3	123.4	124.4	125.8	127.2
D	7780	0	123.2	124.4	125.3	127.2	128.1	129.4	130.7
D	7940	0	126.2	127.6	128.5	130.4	131.2	132.1	133.1
D	8250	0	136.3	137.5	138.3	140.0	140.8	142.2	143.6
D	8475	0	143.6	145.6	146.8	149.6	150.9	154.5	154.1
D	8670	0	152.2	153.1	153.8	155.3	156.1	157.1	158.2
D	8870	0	166.5	168.1	169.2	171.7	172.8	174.0	175.1
D	9030	0	182.7	183.5	183.9	184.9	185.4	186.0	186.7
D	9215	0	197.2	198.3	199	200.5	201.2	202.1	202.9
D	9440	0	211.8	212.5	213	214	214.3	215.1	215.8
D	9585	0	222.6	223.3	223.9	225.3	226.0	227.2	228.3
D	9670	0	230.4	232	232.7	233.9	234.3	234.9	235.6
D	9820	0	239.4	240.7	241.4	242.8	243.5	244.5	245.5
D	9885	0	240.1	242.6	243.3	249.2	250.1	251.1	252.1
D	9915	0	243.3	245.5	246.9	250.8	251.4	252.3	253.2
D	9970	0	248.1	249.2	250.1	252.3	253.2	254.2	255.3
D	10140	0	262.1	263.2	263.8	265.2	265.8	266.5	267.2
D	10300	0	272	272.6	273	274.1	274.7	275.5	276.3
D	10500	0	277.9	279.8	281.1	284.1	284.9	286.1	287.3
D	10700	0	284.7	285.5	286	287.1	287.6	288.2	288.9
D	10850	0	287.6	288.5	289	290.2	290.7	291.4	292.1
D	11040	0	289.8	290.5	291	292.1	292.6	293.4	294.1
D	11315	0	294.9	295.3	295.6	296.4	296.7	297.2	297.6
D	11550	0	300.7	301.5	302.1	303.3	304.0	304.8	305.6
D	11730	0	304.2	305.3	306.0	307.4	307.9	308.6	309.3
D	11845	0	307.6	308.6	309.2	310.7	311.4	312.5	313.6
D	11945	0	313.5	314.6	315.3	317.0	317.7	318.5	319.2
D	12260	0	333.9	335	335.7	336.9	337.5	338.4	339.3
D	12500	0	342.8	344.3	345.3	347.6	348.6	349.5	350.4
D	12730	0	349.4	350.2	350.7	351.8	352.2	352.8	353.3
D	13020	0	359.1	360.1	360.7	362.1	362.7	363.5	364.3
D	13440	0	376.6	377.7	378.4	379.7	380.2	380.9	381.5
D	13840	0	383.4	384.5	385.1	386.6	387.3	388.1	388.8
D	14200	0	385.0	386.0	386.6	388.0	388.6	388.9	389.3
D	15070	0	389.1	389.9	390.4	391.7	392.3	392.9	393.5
D	15520	0	389.9	390.5	390.9	391.8	392.3	392.8	393.4
D	15980	0	393.3	394.3	395.0	396.6	397.4	398.3	399.2
D	16260	0	398.6	399.5	400.0	401.4	402.0	402.6	403.2
D	16680	0	409.9	410.6	411.1	412.2	412.7	413.4	414.1
D	17060	0	420.2	421.1	421.7	423.1	423.8	424.5	425.1
D	17500	0	432.4	433	433.5	434.6	435.1	435.9	436.6
D	17760	0	443	444.0	444.4	445.4	445.7	446.1	446.5
D	18050	0	453.3	454.4	455.1	456.8	457.7	458.7	459.8
D	18180	0	463	463.9	464.5	465.8	466.4	467.2	467.9
D	18580	0	473.3	474.3	474.9	476.3	477.0	477.8	478.5
D	18780	0	484.5	485.8	486.7	488.7	489.6	490.8	492.0
D	19280	0	493.8	494.9	495.6	497.2	498.0	498.9	499.8

Exhibit 2

```
D  19690       0   503.2   504.2   504.8   506.1   506.6   507.2   507.7
D  19980       0   512.7   513.6   514.3   515.8   516.5   517.3   518.1
D  20260       0   543.0   543.8   544.3   545.3   545.7   546.2   546.6
D  20590       0   562.9   563.7   564.3   565.6   566.3   567.1   567.9
D  20750       0   573.0   573.9   574.5   575.9   576.4   577.0   577.6
D  21130       0   583.4   584.4   585.1   586.4   587.0   587.7   588.4
D  21510       0   603.7   604.6   605.3   606.7   607.4   608.1   608.8
D  21910       0   624.4   625.6   626.4   628.3   628.9   629.8   630.6
D  22360       0   644.6   645.8   646.6   648.3   649.3   650.1   650.9
D  22700       0   664.4   665.6   666.5   668.3   668.8   669.6   670.4
D  22980       0   685.5   686.8   687.7   689.7   691.1   692.3   693.4
D  23190       0   693.2   695.6   697.2   701.5   700.4   702.0   703.5
D  23240       0   692.0   694.1   695.7   699.9   702.3   706.3   710.4
D  23280       0   690.4   692.1   693.7   699.9   702.0   706.1   710.2
D  23330       0   697.8   699.8   701.3   704.5   705.6   706.8   708.1
D  23550       0   703.6   704.7   705.4   707.1   707.8   708.6   709.4
D  24100       0   713.6   714.7   715.4   717.1   717.8   718.6   719.4
D  24550       0   723.3   724.3   724.9   726.3   727.0   727.5   728.0
D  24960       0   735.6   737.0   738.0   739.7   740.3   741.2   742.1
D  25370       0   745.9   747.7   748.9   751.7   753.0   754.3   755.5
T DISASTER STREAM FLOOD DAMAGE REDUCTION STUDY
T WATER SURFACE PROFILE DATA
T WITH PROJECT (100 YR DESIGN)
C      3
Y            100     300     500
S    120
*
*  STA NO  100 YR  300 YR  500 YR
*                          (SPF)
D      0       0     3.2     2.9
D    220       0     3.3     3.2
D    430       0     3.5     3.4
D    650       0     3.9     5.0
D    900       0     5.4     6.1
D   1150       0     5.7     6.5
D   1450       0     6.0     6.9
D   1730       0     6.6     7.0
D   2000       0     6.8     7.1
D   2300       0     7.8     7.6
D   2630       0     8.5     8.3
D   2900       0     8.6     8.4
D   2950       0     8.5     8.5
D   3000       0     8.6     8.8
D   3050       0     9.3     9.3
D   3100       0     9.6     9.5
D   3260       0     9.9    10.6
D   3350       0    11.4    10.8
D   3419       0    11.3    10.6
D   3420       0    11.3    10.6
D   3480       0    11.4    12.3
D   3481       0    11.4    12.8
D   3535       0    11.0    12.3
D   3700       0    14.3    15.1
D   3900       0    17.3    17.7
D   4070       0    20.5    21.5
```

Exhibit 2

D	4150	0	24.3	24.9
D	4151	0	24.3	24.9
D	4199	0	26.0	30.6
D	4200	0	22.4	26.2
D	4300	0	28.5	30.6
D	4360	0	33.8	31.1
D	4520	0	35.4	32.5
D	4640	0	35.9	33.3
D	4732	0	35.9	33.5
D	4768	0	36.0	34.8
D	4850	0	37.9	35.6
D	4985	0	45.4	43.4
D	5215	0	49.7	47.5
D	5360	0	63.1	58.5
D	5385	0	73.9	68.2
D	5420	0	76.7	71.3
D	5450	0	76.5	75.5
D	5510	0	76.8	75.7
D	5795	0	82.5	75.8
D	6065	0	90.6	82.8
D	6300	0	98.8	90.3
D	6500	0	103.5	94.0
D	6760	0	108.0	97.4
D	6950	0	111.9	101.1
D	7055	0	114.5	103.7
D	7215	0	118.3	106.7
D	7390	0	123.7	111.9
D	7580	0	128.7	116.2
D	7780	0	133.1	119.9
D	7940	0	136.3	123.0
D	8250	0	147.2	132.6
D	8475	0	155.1	140.4
D	8670	0	164.4	147.6
D	8870	0	179.8	162.0
D	9030	0	197.3	176.9
D	9215	0	213.0	191.2
D	9440	0	228.7	204.8
D	9585	0	240.4	215.3
D	9670	0	248.8	223.6
D	9820	0	258.6	232.0
D	9885	0	259.3	233.9
D	9915	0	262.8	236.7
D	9970	0	267.9	240.2
D	10140	0	283.1	253.7
D	10300	0	293.8	262.8
D	10500	0	300.1	269.7
D	10700	0	307.5	275.2
D	10850	0	310.6	278.1
D	11040	0	313.0	280.0
D	11315	0	318.5	284.7
D	11550	0	324.8	290.6
D	11730	0	328.5	294.3
D	11845	0	332.2	297.5
D	11945	0	338.6	303.3
D	12260	0	360.6	322.9

Exhibit 2

D	12500	0	370.2	331.9
D	12730	0	377.4	337.6
D	13020	0	387.8	347.1
D	13440	0	406.7	364.1
D	13840	0	414.1	370.7
D	14200	0	415.8	372.1
D	15070	0	420.2	375.9
D	15520	0	421.1	376.4
D	15980	0	424.8	380.1
D	16260	0	430.5	385.1
D	16680	0	442.7	395.8
D	17060	0	453.8	405.9
D	17500	0	467.0	417.4
D	17760	0	478.4	428.0
D	18050	0	489.6	438.0
D	18180	0	500.0	447.2
D	18580	0	511.2	457.2
D	18780	0	523.3	468.3
D	19280	0	533.3	477.1
D	19690	0	543.5	486.0
D	19980	0	553.7	495.1
D	20260	0	586.4	524.2
D	20590	0	607.9	543.4
D	20750	0	618.8	553.2
D	21130	0	630.1	563.4
D	21510	0	652.0	582.8
D	21910	0	674.4	603.1
D	22360	0	696.2	622.6
D	22700	0	717.6	641.6
D	22980	0	740.3	662.1
D	23190	0	748.7	670.6
D	23240	0	747.4	669.1
D	23280	0	745.6	667.2
D	23330	0	753.6	674.6
D	23550	0	759.9	679.3
D	24100	0	770.7	689.0
D	24550	0	781.2	698.2
D	24960	0	794.4	710.5
D	25370	0	805.6	720.8

Exhibit 2

THIS FORM IS DESIGNED FOR ELITE TYPEWRITER OR MANUAL ENTRIES

Property Inventory Coding Sheet

Hawaii State Tax Identification Number					1/	2/	3/	4/	5/	6/	7/	8/	9/	Damage to contents of non-residential properties at indicated depth of flooding over first floor. Enter either as a percent of total content value, or in $1,000's, for all three depths			10/	11/	12/	
Division	Zone	Section	Plat	Parcel	Structure Number	Unit Number	R or C	Stream Station Number	V or S	Elevation MSL	Building Type	Assessed Value Of Structure ($1,000's)	Market Value Of Contents For Non-residential Properties ($1,000's)	1 inch	1 foot	3 feet	$ or %	SIC Code	Damage Subarea	Footnote

80 COLUMN KEY PUNCH TRANSCRIPT LAYOUT SHEET

ENG FORM MAY 68 2900 (Local reproduction of this form is authorized after desired information is filled-in.)

SHEET OF SHEETS

Exhibit 3

PROPERTY INVENTORY CODING SHEET

NOTE: All data fields right justified. When entering numerical data, do not use commas, dollar signs, etc., just the numbers. Integer numbers (no decimal): columns 1-18, 33-34, and 72-80. All other numerical data fields are for decimal numbers (for these data, if no decimal is entered, the program assumes that the decimal is after the last column in the field).

1/ Number sequentially, starting with 1. The second structure within the parcel would be numbered 2, etc.
2/ Similar to 1/, the first unit within a structure would be 1, the next would be 2, etc.
3/ Enter R if residential property, C if commercial property.
4/ From hydrologic water surface profile data.
5/ V for properties located in high flow areas (e.g, adjacent to stream), indicating applicability of velocity stage-damage curves; S for properties located in areas subject mainly to standing water flooding.
6/ Elevation of first floor structure.
7/ Building Types:

10 wood on post and beam
15 wood on concrete slab
20 wood on block foundation
25 brick or block on concrete slab
30 metal building
35 reinforced concrete
40 other (can be explained in footnote)

8/ Assessed value of structure taken directly from taxation records.
9/ Enter this data for non-residential properties as obtained by interview, etc. For residential properties, enter nothing, since content value is computed as a function of structure value by program.
10/ If data in content damage fields is entered as a percent of the total value of contents, enter a % sign; if content damage data is entered as $ value, enter a $ sign.
11/ For non-residential property, enter the appropriate Standard Industrial Classification Code.
12/ This is an arbitrarily assigned number, allowing data and computations to be grouped by damage subarea. Sub-areas could be blocks, block groups, segments of stream bank areas with adjoining flood plain land, etc.

Program ignores data in columns 1-14, 72-74, and 79-80 (containing descriptive and/or reference information only). All other data entries are required input for the program.

Exhibit 3

```
* PITEST:  THIS IS A SAMPLE PROPERTY INVENTORY FILE FOR USE AS A REQUIRED
* INPUT DATA FILE TO RUN THE DO DAMAGE PROGRAM.
3  2  2  4   25 1 1C 1300 S  6.4 25    51.1   60.0    0.0    1.6   19.8$554  1
3  2  2  4   60 1 1C 1500 S  6.4 25    49.7   20.4    0.2    1.4    3.2$554  1
3  2  2  6   27 1 1C 2950 S  8.2 25    40.1   36.0    9.6   12.0   36.0$554  1
3  2  3  8   29 1 1C 2960 S  6.3 15    15.7    9.6    0.6    6.2    9.4$580  2
3  2  3  8   29 1 2C 2960 S  6.6 15    15.7   54.0    0.6    1.7    5.8$763  2
3  2  3  6   28 1 4C 2970 S  7.5 15     4.9    7.6    0.4    1.3    6.4$723  2
3  2  3  8   16 1 5C 2990 S  6.7 25    19.7   38.4    9.2   25.0   34.6$572  2 12
3  2  3  8   16 1 4C 3000 S  7.9 25    19.7  108.0     26     69      81%572  2 12
3  2  3  3   10 1 3C 3000 S  3.2 25     0.0   50.4      1     10      57%514  2 2
3  2  3  3   12 1 1C 3000 S 10.2 15    30.0   22.2    4.8    4.8    7.2$614  2
3  2  3  9   14 1 1C 3000 S  8.0 20     1.8   33.6    0.0   14.4   33.6$595  2
3  2  3  3   10 1 2C 3000 S  9.6 15    46.2   84.0    0.8   28.8   84.0$599  2 2
3  2  3  3   11 1 1C 3000 S  9.9 15    30.0  120.0   10.1   39.0   76.2$733  2
3  2  3  8   16 1 2C 3010 S  7.0 25    19.7   24.0      0     40      93%539  2 12
3  2  3  8   16 1 3C 3010 S  7.9 25    19.7    5.4    0.0    1.2    5.4$899  2
3  2  3  3   14 1 2C 3010 S 10.4 15     7.6   54.0    6.0   12.0   54.0$653  2
3  2  3  3   13 1 1C 3010 S 10.3 15    12.7  610.8    1.2    1.2    7.2$597  2
3  2  3  3   14 1 1C 3010 S 10.4 15     7.6   49.2    2.2   34.8   36.6$599  2
3  2  3  7   10 1 3C 3010 S 10.1 15    20.5   18.0    0.8    5.3   17.4$614  2
3  2  3  7   10 1 2C 3010 S 10.6 15    20.5   20.4    3.6    6.0   16.8$595  2
3  2  3  7   10 1 1C 3010 S 10.6 15    20.5  108.0    7.0   13.8   88.6$561  2
3  2  3  8   16 1 1C 3020 S  7.8 25    19.7  150.0      0     45      93%539  2 12
3  2  3  3   15 1 2C 3020 S 10.4 15     8.0  186.0    9.0  135.6  186.0$562  2
3  2  3  3   15 1 1C 3020 S 10.4 15     8.0    3.4    0.3    0.3    3.4$899  2
3  2  3  3    5 1 2C 3030 S  4.2 25     0.0    6.0    1.2    3.6    6.0$601  2 12
3  2  3  8   15 1 1C 3030 S  6.5 15    16.7   82.8     10     50      97%722  2
3  2  3  7   11 1 1C 3030 S 10.0 25   432.0  192.0    0.0    0.5    1.1$539  2 11
3  2  3  8   14 1 2C 3030 S  6.8 15    15.0   72.0      0     10      60%599  2
3  2  3  3    5 1 1C 3030 S 10.6 25   270.8   96.0    6.0    9.6   36.0$601  2 12
3  2  3  8   14 1 1C 3030 S  6.8 15    15.0  102.0    0.0    1.0   46.2$899  2
3  2  3  8   15 1 2C 3030 S  7.7 15    16.7   30.0    0.8    2.8   15.6$563  2
3  2  3  9   39 1 1C 3030 S  8.8 25    58.3   37.8    0.6   18.6   31.0$571  2
3  2  3  8   13 1 1C 3040 S  6.6 15    15.0    4.8     .5     .5      50%546  2 8
3  2  3  7   30 1 1C 3040 S  9.8 15    14.2   12.0    0.2    6.0   10.9$614  2 6
3  2  3  7   30 1 2C 3040 S  9.6 15    14.0  132.0    6.0   58.0  108.6$565  2 6
3  2  3  8   12 2 1C 3040 S  7.3 25    48.0   42.0    2.4    9.6   18.0$599  2 20
3  2  3  3   10 1 1C 3050 S 11.1 15    46.2   28.2    0.3    6.2   20.4$580  2 26
3  2  3  7   12 1 1C 3050 S  9.5 15    72.0    0.0      0      0       0%     2 11
3  2  3  7   12 2 1C 3050 S 13.1 20     5.0    0.0      0      0       0%     2 11
3  2  3  7   15 1 2C 3060 S  9.3 15     7.8   84.6    0.2   24.2   54.0$563  2 6
3  2  3  7   15 1 1C 3060 S  9.8 15     7.8   42.0    6.0   18.0   42.0$893  2 6
3  2  3  8   18 2 1C 3070 S  8.0 25    14.8   54.0      5     40      80%599  2 13
3  2  3  9    5 2 1R 3230 S 12.8 10    0.86                                   2 20
3  2  3  9    6 2 1R 3270 S 16.0 10    3.96                                   2 20
3  2  3  9   10 1 1R 3280 S 12.8 10    2.40                                   2
3  2  3  9   10 1 2R 3300 S 12.8 10    2.40                                   2
3  2  3  9    7 3 1R 3310 S 16.0 10    2.16                                   2 20
3  2  3  7   32 2 1R 3320 S 21.9 10    1.20                                   2
3  2  2  8    5 3 1R 3610 V 17.6 10    2.88                                   3 25
3  2  2  8    1 2 1R 3610 S 20.0 10    5.28                                   3 20
3  2  3 10    5 3 1R 3630 S 14.4 10    1.56                                   3 1
3  2  3 10    5 2 1R 3660 S 14.4 10    1.56                                   3 1
3  2  3 10    5 1 1R 3660 S 14.4 10    1.56                                   3 1
```

Exhibit 4

```
3  2  3 11   8 2 1R 3680 S 20.8 10     1.56                                      3  6
3  2  2  8  30 3 1R 4000 S 21.6 10     2.76                                      3
3  2  2  8  30 1 1R 4000 V 20.0 10     2.76                                      3
3  2  2  8  30 2 1R 4000 S 20.8 10     2.76                                      3
3  2  2  8   9 1 1R 4030 S 30.4 10     1.44                                      3
3  2  2  8  13 4 1R 4040 S 23.2 10     1.92                                      3
3  2  2  8  13 4 2R 4040 S 23.2 10     1.92                                      3
3  2  3 11   4 3 1R 4050 S 22.4 10     1.68                                      3 20
3  2  3 11   4 2 1R 4050 S 22.4 10     1.68                                      3 20
3  2  3 19   6 1 1R 5300 S 75.2 10     7.20                                      4
3  2  3 18  70 1 1R 5340 S 73.6 10     1.20                                      3
3  2  3 18   1 1 1R 5390 V 71.2 10    10.32                                      3
3  2  3 19  16 1 6R 5480 S 64.0 25    16.80                                      4  3
3  2  3 19  38 2 1R 5500 S 64.0 15    12.00                                      4  3
3  2  3 19  38 1 3R 5500 S 65.6 25    10.80                                      4  5
3  2  3 19  27 1 1R 6110 V 80.8 10    18.00                                      4  2
3  2  3 41  20 3 1R 6240 V 84.0 10     6.36                                      4
3  2  3 41  20 2 1R 6435 V 84.8 20     6.36                                      4
3  2  3 41  20 1 1R 6550 V 86.4 10     6.36                                      4
*  THE PROGRAM WILL IGNORE LINES STARTING WITH AN ASTERISK (*) IN COLUMN
*  1, SO THAT DOCUMENTATION COMMENTS CAN BE ENTERED IN THE PROPERTY INVENTORY
*  INPUT FILE, OR ANY OF THE OTHER INPUT FILES USED IN THE DO DAMAGE PROGRAM.
*  TWO EXAMPLES OF VERY USEFUL COMMENTS FOR USE IN DOCUMENTING PROPERTY INVEN-
*  TORY FILES ARE (1) GENERAL NOTES REGARDING SUCH THINGS AS PRICE LEVEL,
*  CONDITION, ETC., AND (2) FOOTNOTES (FROM COLUMNS 79-80 OF INVENTORY ENTRIES)
*  AND DESCRIPTIVE INFORMATION REGARDING SUBAREA OR REACH BOUNDARIES.  IT IS
*  ALSO A GOOD IDEA TO ENTER THE NAME OF THE FILE SO THAT HARD COPIES WILL
*  BE BETTER REFERENCED.
```

Exhibit 4

```
*        1         2         3         4         5         6         7
*234567890123456789012345678901234567890123456789012345678901234567890
FT       15         5
```

(Number of feet and number of building type curve sets, respectively)

```
BT       10
*       -8  -7  -6  -5  -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9  10
SS       0   0   0   0   0   0   0   0   0 .18 .25 .30 .34 .37 .39 .41 .43 .45 .47
SV       0   0   0   0   0 .15 .17 .20 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
CS       0   0   0   0   0   0   0   0   0 .26 .40 .51 .61 .67 .72 .76 .79 .81 .83
CV       0   0   0   0   0 .02 .04 .06 .11 .40 .85 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
BT       15
*       -8  -7  -6  -5  -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9  10
SS       0   0   0   0   0   0   0   0   0 .18 .25 .30 .34 .37 .39 .41 .43 .45 .47
SV       0   0   0   0   0   0   0   0 .23 .43 .62 .81 1.0 1.0 1.0 1.0 1.0 1.0 1.0
CS       0   0   0   0   0   0   0   0   0 .26 .40 .51 .61 .67 .72 .76 .79 .81 .83
CV       0   0   0   0   0   0   0   0 .11 .40 .85 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
BT       20
*       -8  -7  -6  -5  -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9  10
SS       0   0   0   0   0   0   0   0   0 .18 .25 .30 .34 .37 .39 .41 .43 .45 .47
SV       0   0   0   0   0   0   0   0 .23 .43 .62 .81 1.0 1.0 1.0 1.0 1.0 1.0 1.0
CS       0   0   0   0   0   0   0   0   0 .26 .40 .51 .61 .67 .72 .76 .79 .81 .83
CV       0   0   0   0   0   0   0   0 .11 .40 .85 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
BT       25
*       -8  -7  -6  -5  -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9  10
SS       0   0   0   0   0   0   0   0   0 .18 .25 .30 .34 .37 .39 .41 .43 .45 .47
SV       0   0   0   0   0   0 .01 .02 .13 .34 .45 .54 .61 .66 .71 .75 .78 .81 .83
CS       0   0   0   0   0   0   0   0   0 .26 .40 .51 .61 .67 .72 .76 .79 .81 .83
CV       0   0   0   0   0   0   0   0   0 .49 .66 .76 .82 .87 .91 .93 .94 .95 .96
BT       30
*       -8  -7  -6  -5  -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9  10
SS       0   0   0   0   0   0   0   0   0 .18 .25 .30 .34 .37 .39 .41 .43 .45 .47
SV       0   0   0   0   0   0   0   0 .23 .43 .62 .81 1.0 1.0 1.0 1.0 1.0 1.0 1.0
CS       0   0.  0   0   0   0   0   0   0 .26 .40 .51 .61 .67 .72 .76 .79 .81 .83
CV       0   0   0   0   0   0   0   0 .11 .40 .85 1,0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
*
*        1         2         3         4         5         6         7
*23456789012345678901234567890123456789012345678901234567890123456789
*
* DOCTEST:  THIS IS A DEPTH DAMAGE CURVE INPUT FILE FØR USE
* IN A TEST RUN ØF THE PRØGRAM CALLED DØ DAMAGE.  IT CØNTAINS STANDARD-
* IZED DEPTH DAMAGE CURVES FØR STRUCTURES AND CONTENTS, BØTH FØR HI
* VELØCITY AND LØ VELØCITY FLØW ZØNES DEFINED BY THE USER.
* THE CURVES RELATE FEET ØF FLØØDING ØVER THE FIRST FLØØR TØ DAMAGE
* EXPRESSED AS A FRACTIØN ØF TØTAL MARKET VALUE.
* THESE CURVES DØ NØT APPLY IN THE CASE ØF NØNRESIDENTIAL CØNTENTS,
* WHØSE CØNTENT DAMAGE DATA IS ØBTAINED DIRECTLY (BY INTERVIEW, FØR
* EXAMPLE) AND ENTERED IN THE PRØPERTY INVENTØRY DATA INPUT FILE.
* ENTRIES THAT START WITH AN ASTERISK IN CØLUMN 1 ARE FØR DØCUMENTATIØN
* AND GUIDANCE ØNLY, SUCH AS THE CØLUMN NUMBERS AT THE BEGINNING AND
* END ØF THE DATA BLØCK ABØVE, AND ARE IGNØRED BY THE PRØGRAM.
* NØTE:  ALTHØUGH CØLUMN HEADING GUIDELINES ARE INCLUDED AT THE TØP ØF THIS
* SAMPLE FILE, THE CURRENT VERSIØN ØF THE PRØGRAM WILL NØT RUN IF THE DEPTH
* DAMAGE CURVE INPUT DATA FILE STARTS ØUT WITH A CØMMENT ENTRY.
EØT..
```

Feet of flooding over first floor

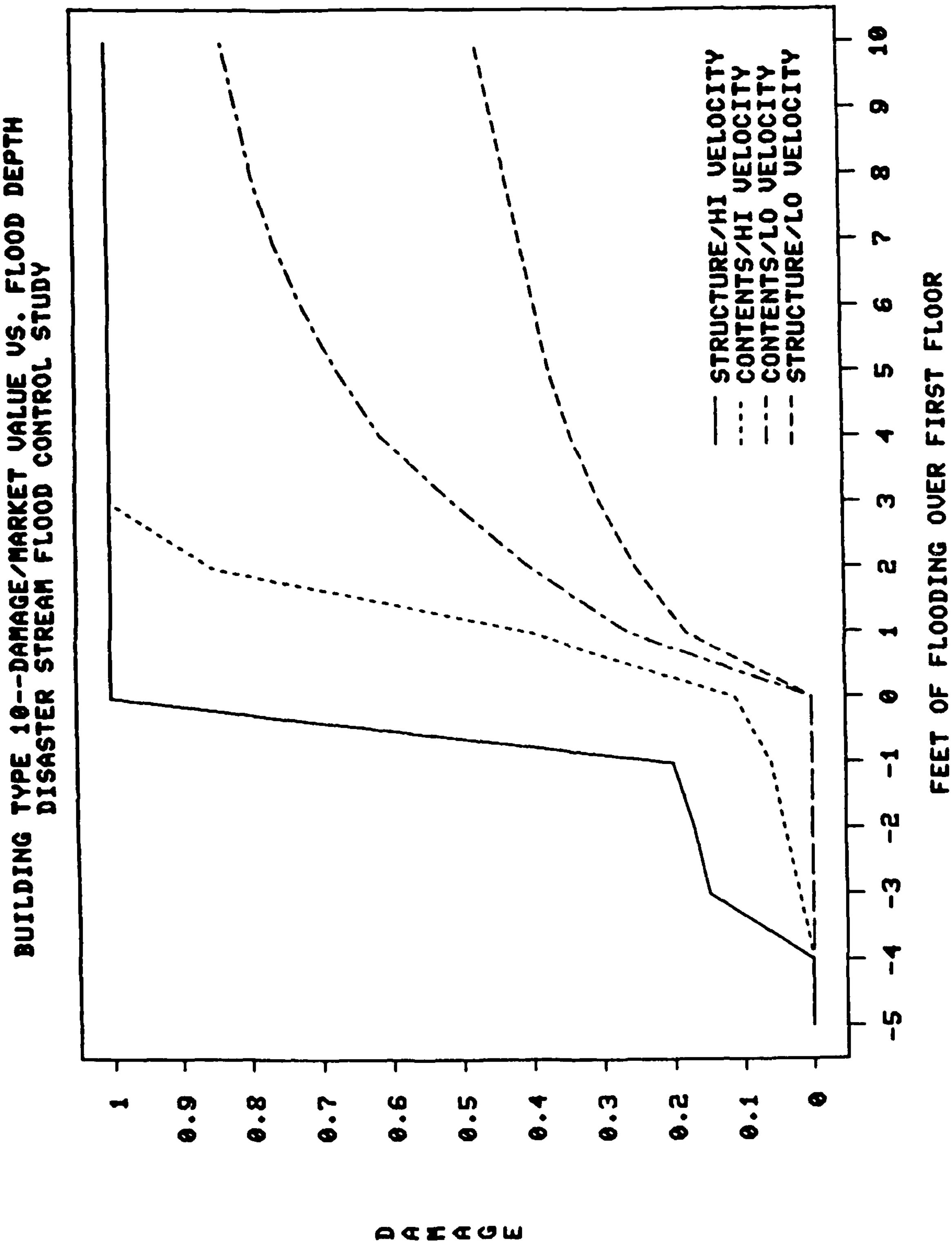
Building Types:

10 wood on post and beam
15 wood on concrete slab
20 wood on block foundation
25 brick or block on concrete slab
30 metal building
35 reinforced concrete
40 other (can be explained in footnote)

(Building types may be arbitrarily set up by user. The building type code entered in the property inventory data file is used by the program to link up with the appropriate depth damage curve)

SS--structure, low velocity zone
SV-- " , high " "
CS--contents, low " "
CV-- " , high " "

Exhibit 5



BUILDING TYPE 10--DAMAGE/MARKET VALUE VS. FLOOD DEPTH
DISASTER STREAM FLOOD CONTROL STUDY
STRUCTURE/HI VELOCITY
CONTENTS/HI VELOCITY
CONTENTS/LO VELOCITY
STRUCTURE/LO VELOCITY
DAMAGE
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
FEET OF FLOODING OVER FIRST FLOOR

Exhibit 6

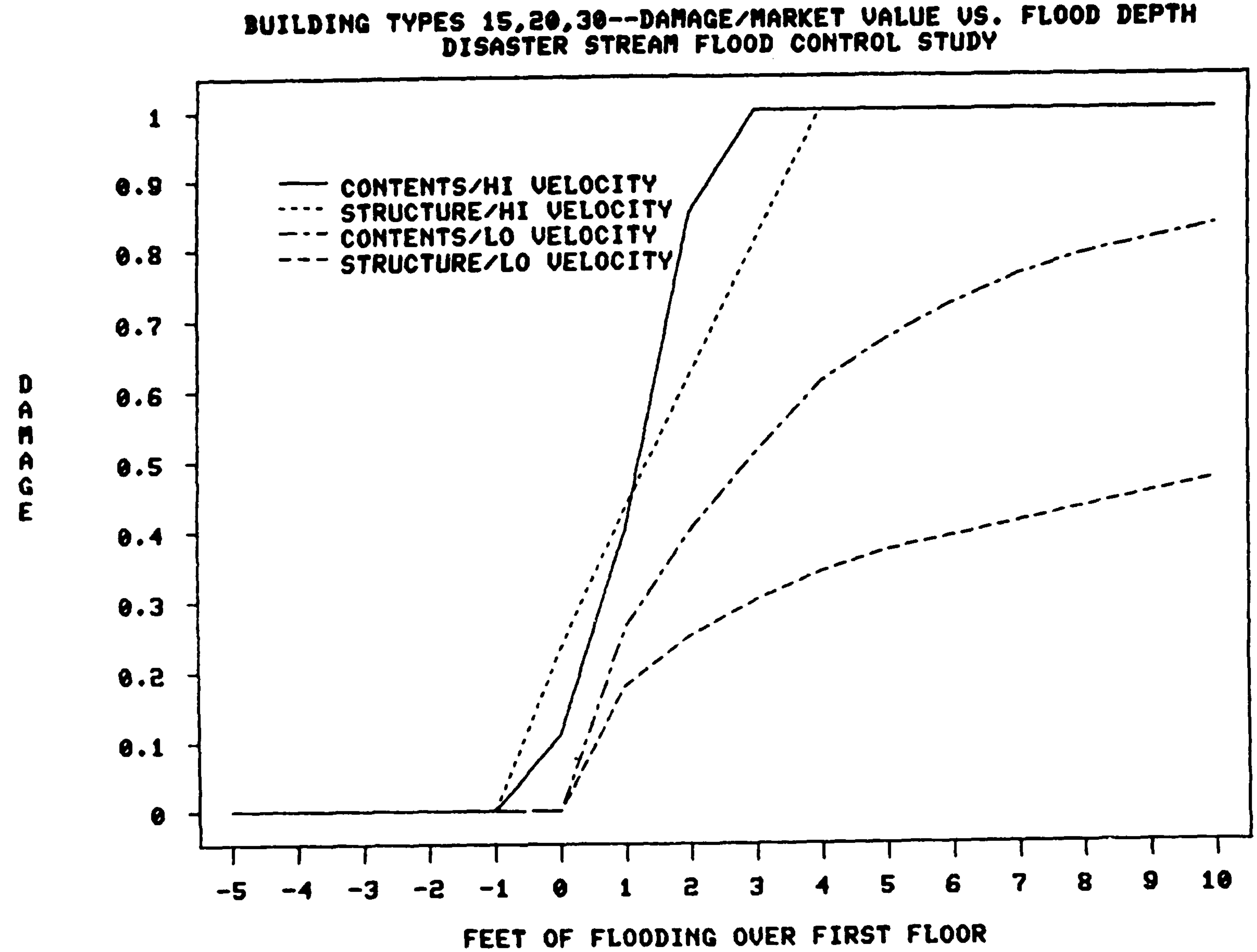

BUILDING TYPES 15,20,30--DAMAGE/MARKET VALUE VS. FLOOD DEPTH
DISASTER STREAM FLOOD CONTROL STUDY
CONTENTS/HI VELOCITY
STRUCTURE/HI VELOCITY
CONTENTS/LO VELOCITY
STRUCTURE/LO VELOCITY
DAMAGE
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
FEET OF FLOODING OVER FIRST FLOOR

Exhibit 7

BUILDING TYPE 25--DAMAGE/MARKET VALUE VS. FLOOD DEPTH
DISASTER STREAM FLOOD CONTROL STUDY

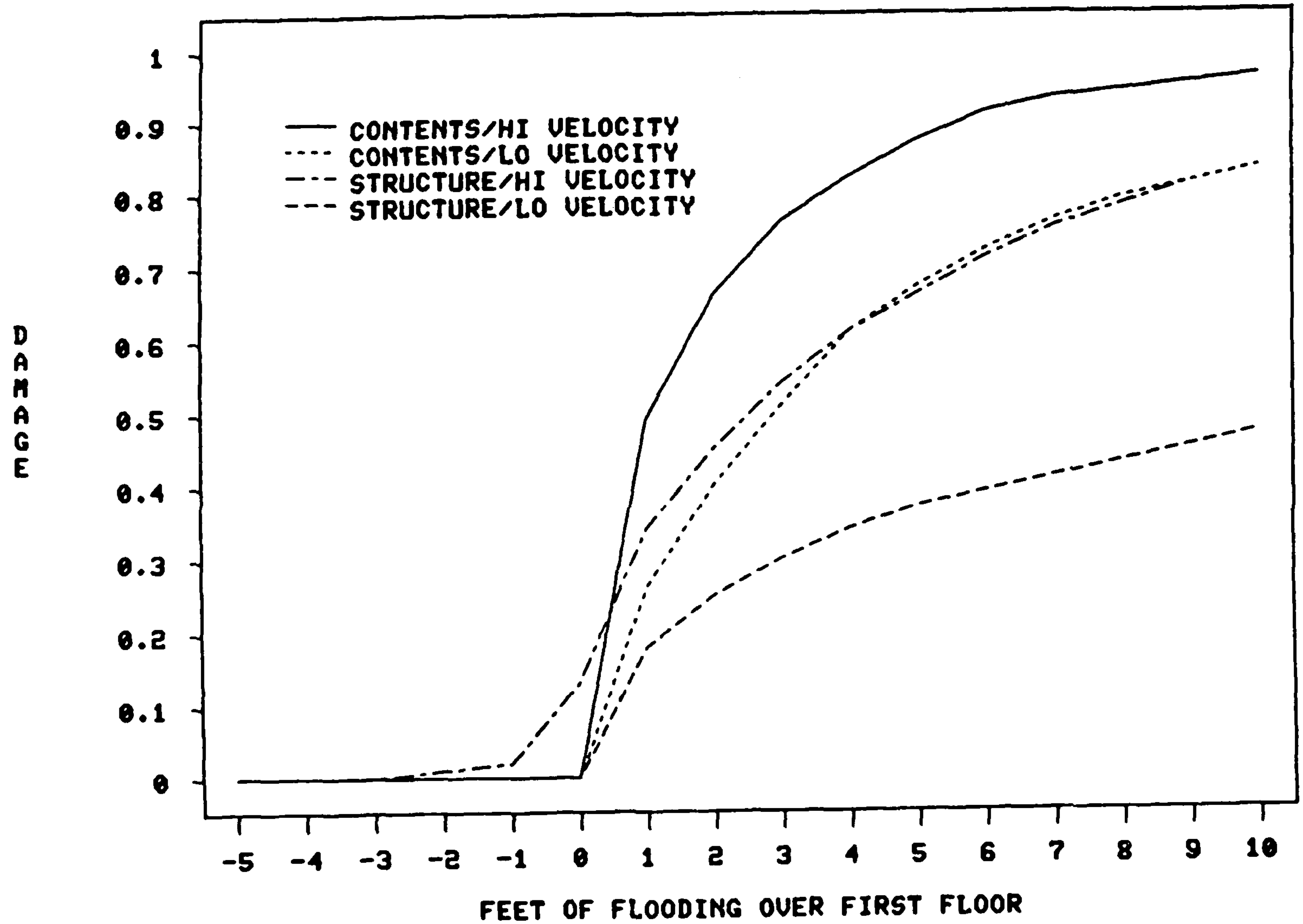


Exhibit 8

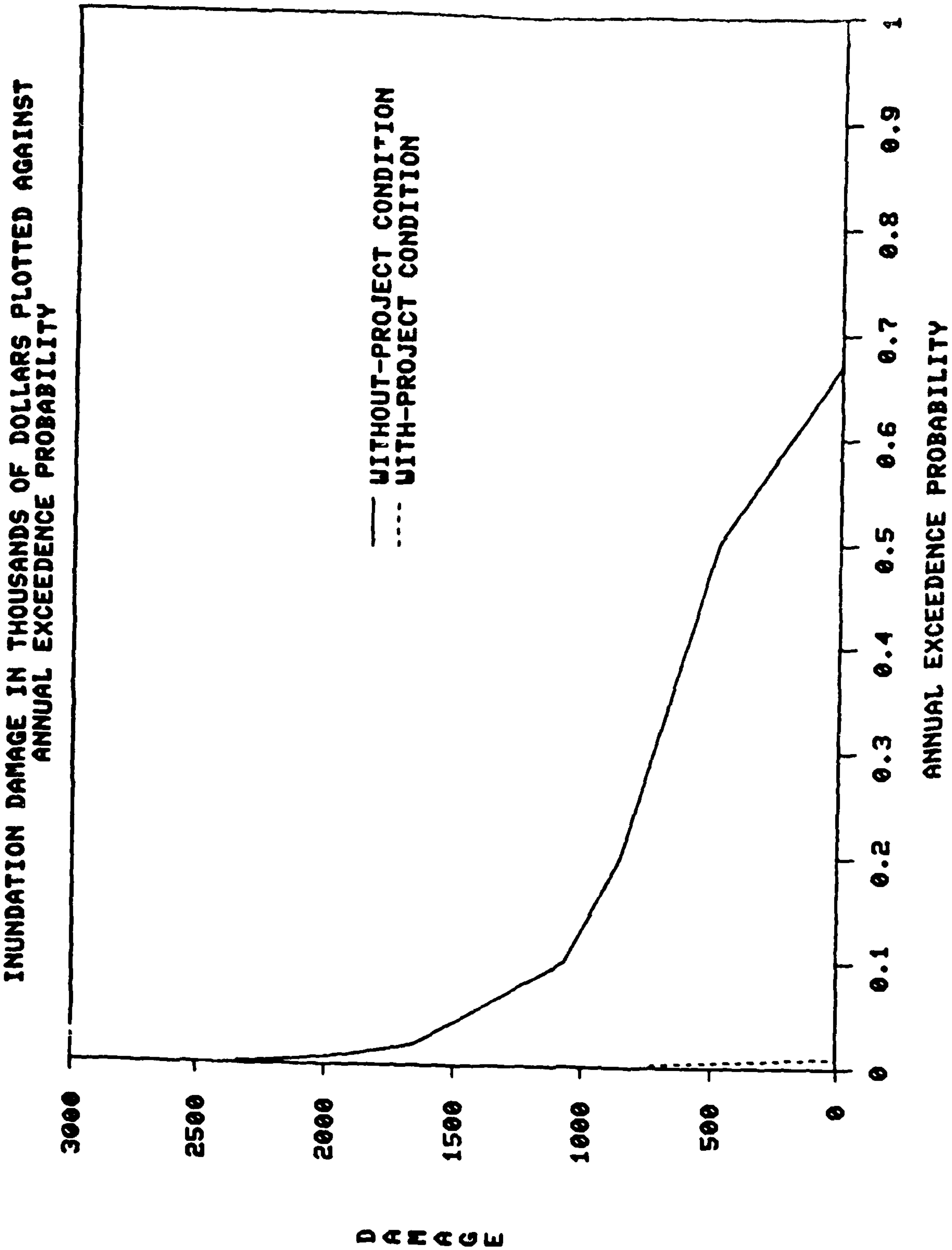

INUNDATION DAMAGE IN THOUSANDS OF DOLLARS PLOTTED AGAINST ANNUAL EXCEEDENCE PROBABILITY
WITHOUT-PROJECT CONDITION
WITH-PROJECT CONDITION
DAMAGE
3000
2500
2000
1500
1000
500
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
ANNUAL EXCEEDENCE PROBABILITY

Exhibit 9

```
DC DAMAGE
BEGIN DAMAGE
             AVERAGE ANNUAL DAMAGE AND BENEFITS PROGRAM

W2 = PROPERTY DAMAGE CALCULATION DATA BASE
W6 = CALCULATION TRACE (DEBUG) FILE
HOW MANY WATER SURFACE PROFILE DATA SETS? (1 OR 2)
* 2
ENTER RATIO OF ASSESSED STRUCTURE VALUE
             TO MARKET VALUE
* .6
ENTER PROJECT --
* DISASTER STREAM, ANYWHERE, U.S.A.
ENTER PRICE LEVEL --
* OCTOBER 1982
ENTER LEVEL OF PROTECTION --
* 100 YEAR
PROJECT -- DISASTER STREAM, ANYWHERE, U.S.A.
PRICE LEVEL -- OCTOBER 1982
LEVEL OF PROTECTION -- 100 YEAR
ANY CHANGES? (Y/N)
* N

===>          WATER SURFACE PROFILES
INPUT FILE NAME ?
* WSPTEST
WSPTEST   OPENED

===>          STAGE DAMAGE CURVES
INPUT FILE NAME ?
* DDCTEST
DDCTEST   OPENED

===>          PROPERTY INVENTORY
INPUT FILE NAME ?
* PITTEST
PITEST    OPENED
ENTER  STAGE-DAMAGE OPTION --
      1 =  LOW VELOCITY
      2 =  HIGH VELOCITY
      3 =  USE PROPERTY INVENTORY CODE
* 3
STAGE-DAMAGE OPTION --  USE PROPERTY INVENTORY CODE
ANY CHANGES ? (Y/N)
* N

CALCULATING DAMAGES ...

DISASTER STREAM FLOOD DAMAGE REDUCTION STUDY
WATER SURFACE PROFILE DATA  FILE:  WSPTEST
WITHOUT PROJECT

DISASTER STREAM FLOOD DAMAGE REDUCTION STUDY
WATER SURFACE PROFILE DATA
WITH PROJECT (100 YR DESIGN)

CALCULATIONS DONE
ENTER OPTION(STOP,DATA,CALC,REPORT,GRAPH,HELP)
REPORT
```

If structure values are entered as assessed values in the property inventory data file, they will be converted by the program using this variable. If market values are used, enter 1.0.

For documentation

* User entry

Uses low velocity depth damage curves for all units, or high velocity curves for all units, or uses curves as indicated in the property inventory file.

Exhibit 10

Sample Interactive Session

```
  ===>          GENERATED REPORTS
  OUTPUT FILE NAME ?
* TESTOUT
  TESTOUT   OPENED
  WHAT REPORTS DO YOU NEED?
      1 = MINIMUM SUMMARY REPORT
          (ANNUAL DAMAGE TOTALS BY RETURN PERIOD)
      2 = FULL PROPERTY INVENTORY CALCULATIONS
          (BY RETURN PERIOD)
      3 = SUBTOTALS BY SUB-AREA
      4 = SUBTOTALS BY RESIDENTIAL/NON-RES.
      5 = SUMMARY OF STRUCTURES AND UNITS
* 1
  MORE REPORTS ? (Y OR N)
* Y
  WHAT REPORTS DO YOU NEED?
* 2
  MORE REPORTS ? (Y OR N)
* Y
  WHAT REPORTS DO YOU NEED?
* 3
  MORE REPORTS ? (Y OR N)
* Y
  WHAT REPORTS DO YOU NEED?
* 4
  MORE REPORTS ? (Y OR N)
* Y
  WHAT REPORTS DO YOU NEED?
* 5
  MORE REPORTS ? (Y OR N)
* N
  ENTER OPTION(STOP,DATA,CALC,REPORT,GRAPH,HELP)
* STOP
  FILES         CONTENTS
  -----         --------
  TESTOUT       REPORT FILE
  W2            PROPERTY DAMAGE DATA BASE
  W6            CALCULATION TRACES - DEBUGGING
  PITEST        PROPERTY INVENTORY INPUT FILE
  WSPTEST       WATER SURFACE PROFILE INPUT FILE
  DDCTEST       STAGE DAMAGE CURVE INPUT FILE
```

* User entry

Exhibit 10

Sample Output

PROJECT -- DISASTER STREAM, ANYWHERE, U.S.A.
PRICE LEVEL -- OCTOBER 1982
LEVEL OF PROTECTION -- 100 YEAR
PROPERTY INVENTORY INPUT FILE NAME -- PITEST
WATER SURFACE PROFILE INPUT FILE NAME -- WSPTEST
STAGE-DAMAGE CURVES INPUT FILE NAME -- DDCTEST
STAGE-DAMAGE OPTION -- USE PROPERTY INVENTORY CODE

DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR
RESIDENTIAL AND NON-RESIDENTIAL STRUCTURES AND CONTENTS
(DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	166.447	315.091	481.539
5.0	272.733	579.592	852.325
10.0	335.470	729.175	1064.645
50.0	556.714	1095.288	1652.001
100.0	649.609	1236.840	1886.448
300.0	757.349	1406.938	2164.287
500.0	825.438	1511.055	2336.494

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	222.685	487.978	710.663
500.0	228.745	508.617	737.362

AVERAGE ANNUAL BENEFITS

	AVERAGE ANNUAL DAMAGES		
CONDITION	STRUCTURES	CONTENTS	TOTAL
W/O PROJECT	159.273	324.318	483.590
WITH PROJECT	1.501	3.308	4.809
	---------------	---------------	---------------
BENEFIT	157.772	321.009	478.781

Exhibit 11

PROJECT -- DISASTER STREAM, ANYWHERE, U.S.A.
LEVEL OF PROTECTION -- 100 YEAR
PROPERTY INVENTORY INPUT FILE NAME -- PITEST
STAGE-DAMAGE OPTION -- USE PROPERTY INVENTORY CODE
(DAMAGE AMOUNT IN $ THOUSANDS)

The following four pages of sample output show the development of the detailed calculations leading to the aggregate damage amounts. The output for which there is a 1 in the last column with the heading J# are for the without-project, or first hydrologically defined condition. The output pages with the 2 in the last column are from the with-project, or second, condition. These pages are just a portion of the test run and show results for both residential and non-residential properties (indicated in CR column). The without and with-project results attached cover roughly the same portion of the property inventory data file.

Exhibit 11

Sample Output

RETN PER.	BLG COD	C R	S A	STA-TION	ELEVA-TION	FLOOD HT(FT)	OVER 1-FLR	STRUCTURE $-VALUE	STRUCTURE .%-DMG	STRUCTURE $-DAMAGE	CONTENT $-VALUE	CONTENT .%-DMG	CONTENT $-DAMAGE	TOTAL $-DAMAGE	(TAX MAP KEY)							J #
1.5	25	C	1	1300	6.	0.0	-6.4	85.	0.00	0.000	60.	0.00	0.000	0.000	3	2	2	4	25	1	1	1
2.0	25	C	1	1300	6.	5.4	-1.0	85.	0.00	0.000	60.	0.00	0.000	0.000	3	2	2	4	25	1	1	1
5.0	25	C	1	1300	6.	6.9	0.5	85.	0.10	8.431	60.	0.01	0.815	9.246	3	2	2	4	25	1	1	1
10.0	25	C	1	1300	6.	7.6	1.2	85.	0.19	16.522	60.	0.06	3.420	19.942	3	2	2	4	25	1	1	1
50.0	25	C	1	1300	6.	9.2	2.8	85.	0.29	24.698	60.	0.30	17.980	42.678	3	2	2	4	25	1	1	1
100.0	25	C	1	1300	6.	9.6	3.2	85.	0.31	26.231	60.	0.36	21.620	47.851	3	2	2	4	25	1	1	1
300.0	25	C	1	1300	6.	10.1	3.7	85.	0.33	28.105	60.	0.44	26.625	54.730	3	2	2	4	25	1	1	1
500.0	25	C	1	1300	6.	10.6	4.2	85.	0.35	29.468	60.	0.51	30.720	60.188	3	2	2	4	25	1	1	1
1.5	25	C	1	1500	6.	0.0	-6.4	83.	0.00	0.000	20.	0.00	0.000	0.000	3	2	2	4	60	1	1	1
2.0	25	C	1	1500	6.	5.7	-0.7	83.	0.00	0.000	20.	0.00	0.000	0.000	3	2	2	4	60	1	1	1
5.0	25	C	1	1500	6.	7.2	0.8	83.	0.15	12.194	20.	0.06	1.162	13.356	3	2	2	4	60	1	1	1
10.0	25	C	1	1500	6.	7.9	1.5	83.	0.22	17.913	20.	0.09	1.866	19.779	3	2	2	4	60	1	1	1
50.0	25	C	1	1500	6.	9.4	3.0	83.	0.30	24.909	20.	0.16	3.216	28.125	3	2	2	4	60	1	1	1
100.0	25	C	1	1500	6.	9.8	3.4	83.	0.32	26.234	20.	0.18	3.576	29.811	3	2	2	4	60	1	1	1
300.0	25	C	1	1500	6.	10.4	4.0	83.	0.34	28.208	20.	0.20	4.116	32.324	3	2	2	4	60	1	1	1
500.0	25	C	1	1500	6.	10.9	4.5	83.	0.36	29.495	20.	0.22	4.582	34.077	3	2	2	4	60	1	1	1
1.5	25	C	1	2950	8.	0.0	-8.2	67.	0.00	0.000	36.	0.00	0.000	0.000	3	2	2	6	27	1	1	1
2.0	25	C	1	2950	8.	7.9	-0.3	67.	0.00	0.000	36.	0.00	0.000	0.000	3	2	2	6	27	1	1	1
5.0	25	C	1	2950	8.	8.8	0.6	67.	0.11	7.218	36.	0.30	10.953	18.171	3	2	2	6	27	1	1	1
10.0	25	C	1	2950	8.	9.2	1.0	67.	0.18	12.030	36.	0.33	12.000	24.030	3	2	2	6	27	1	1	1
50.0	25	C	1	2950	8.	10.2	2.0	67.	0.25	16.708	36.	0.67	24.000	40.708	3	2	2	6	27	1	1	1
100.0	25	C	1	2950	8.	10.5	2.3	67.	0.26	17.711	36.	0.77	27.600	45.311	3	2	2	6	27	1	1	1
300.0	25	C	1	2950	8.	11.0	2.8	67.	0.29	19.382	36.	0.93	33.600	52.982	3	2	2	6	27	1	1	1
500.0	25	C	1	2950	8.	11.6	3.4	67.	0.32	21.119	36.	1.00	36.000	57.119	3	2	2	6	27	1	1	1
1.5	15	C	2	2960	6.	0.0	-6.3	26.	0.00	0.000	10.	0.00	0.000	0.000	3	2	3	8	29	1	1	1
2.0	15	C	2	2960	6.	7.9	1.6	26.	0.22	5.846	10.	0.75	7.192	13.038	3	2	3	8	29	1	1	1
5.0	15	C	2	2960	6.	8.9	2.6	26.	0.28	7.274	10.	0.91	8.696	15.970	3	2	3	8	29	1	1	1
10.0	15	C	2	2960	6.	9.3	3.0	26.	0.30	7.798	10.	0.97	9.336	17.134	3	2	3	8	29	1	1	1
50.0	15	C	2	2960	6.	10.3	4.0	26.	0.34	8.855	10.	0.98	9.400	18.255	3	2	3	8	29	1	1	1
100.0	15	C	2	2960	6.	10.6	4.3	26.	0.35	9.101	10.	0.98	9.400	18.501	3	2	3	8	29	1	1	1
300.0	15	C	2	2960	6.	11.1	4.8	26.	0.36	9.493	10.	0.98	9.400	18.893	3	2	3	8	29	1	1	1
500.0	15	C	2	2960	6.	11.6	5.3	26.	0.38	9.860	10.	0.98	9.400	19.260	3	2	3	8	29	1	1	1
1.5	15	C	2	2960	7.	0.0	-6.6	26.	0.00	0.000	54.	0.00	0.000	0.000	3	2	3	8	29	1	2	1
2.0	15	C	2	2960	7.	7.9	1.3	26.	0.20	5.296	54.	0.04	2.356	7.652	3	2	3	8	29	1	2	1
5.0	15	C	2	2960	7.	8.9	2.3	26.	0.26	6.862	54.	0.08	4.283	11.165	3	2	3	8	29	1	2	1
10.0	15	C	2	2960	7.	9.3	2.7	26.	0.28	7.405	54.	0.09	5.103	12.508	3	2	3	8	29	1	2	1
50.0	15	C	2	2960	7.	10.3	3.7	26.	0.33	8.541	54.	0.13	7.153	15.694	3	2	3	8	29	1	2	1
100.0	15	C	2	2960	7.	10.6	4.0	26.	0.34	8.855	54.	0.14	7.768	16.623	3	2	3	8	29	1	2	1
300.0	15	C	2	2960	7.	11.1	4.5	26.	0.35	9.258	54.	0.16	8.793	18.051	3	2	3	8	29	1	2	1
500.0	15	C	2	2960	7.	11.6	5.0	26.	0.37	9.703	54.	0.18	9.982	19.685	3	2	3	8	29	1	2	1
1.5	15	C	2	2970	8.	0.0	-7.5	8.	0.00	0.000	8.	0.00	0.000	0.000	3	2	3	8	28	1	4	1
2.0	15	C	2	2970	8.	7.9	0.4	8.	0.08	0.647	8.	0.10	0.750	1.397	3	2	3	8	28	1	4	1
5.0	15	C	2	2970	8.	8.9	1.4	8.	0.21	1.710	8.	0.31	2.371	4.081	3	2	3	8	28	1	4	1
10.0	15	C	2	2970	8.	9.3	1.8	8.	0.24	1.939	8.	0.45	3.391	5.330	3	2	3	8	28	1	4	1
50.0	15	C	2	2970	8.	10.3	2.8	8.	0.29	2.376	8.	0.78	5.941	8.317	3	2	3	8	28	1	4	1
100.0	15	C	2	2970	8.	10.6	3.1	8.	0.30	2.489	8.	0.84	6.400	8.889	3	2	3	8	28	1	4	1
300.0	15	C	2	2970	8.	11.1	3.6	8.	0.32	2.653	8.	0.84	6.400	9.053	3	2	3	8	28	1	4	1
500.0	15	C	2	2970	8.	11.7	4.2	8.	0.35	2.821	8.	0.84	6.400	9.221	3	2	3	8	28	1	4	1
1.5	25	C	2	2990	7.	0.0	-6.7	33.	0.00	0.000	38.	0.00	0.000	0.000	3	2	3	8	16	1	5	1
2.0	25	C	2	2990	7.	8.0	1.3	33.	0.20	6.554	38.	0.69	26.344	32.898	3	2	3	8	16	1	5	1

Exhibit 11

Sample Output

RETN PER.	HLG LOD	C R	S A	STA-TION	ELEVA-TION	FLOOD HT(FT)	OVER 1-FLR	STRUCTURE $-VALUE	STRUCTURE %-DMG	STRUCTURE $-DAMAGE	CONTENT $-VALUE	CONTENT %-DMG	CONTENT $-DAMAGE	TOTAL $-DAMAGE	(TAX MAP KEY)	J #
500.0	10	R	2	3270	16.	13.3	-2.7	7.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 6 2 1	1
500.0	10	R	2	3270	15.	13.7	-2.3	7.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 6 2 1	1
1.5	10	R	2	3280	13.	0.0	-12.8	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	1
2.0	10	R	2	3280	13.	9.5	-3.3	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	1
5.0	10	R	2	3280	13.	11.0	-1.8	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	1
10.0	10	R	2	3280	13.	11.1	-1.9	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	1
50.0	10	R	2	3280	13.	12.2	-0.6	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	1
100.0	10	R	2	3280	13.	13.1	0.3	4.	0.05	0.192	6.	0.07	0.420	0.612	3 2 3 9 10 1 1	1
300.0	10	R	2	3280	13.	13.6	0.8	4.	0.15	0.600	6.	0.22	1.313	1.913	3 2 3 9 10 1 1	1
500.0	10	R	2	3280	13.	14.1	1.3	4.	0.20	0.804	6.	0.30	1.830	2.634	3 2 3 9 10 1 1	1
1.5	10	R	2	3300	13.	0.0	-12.8	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	1
2.0	10	R	2	3300	13.	9.5	-3.0	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	1
5.0	10	R	2	3300	13.	11.1	-1.7	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	1
10.0	10	R	2	3300	13.	11.5	-1.3	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	1
50.0	10	R	2	3300	13.	12.3	-0.5	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	1
100.0	10	R	2	3300	13.	13.7	0.9	4.	0.17	0.672	6.	0.24	1.470	2.142	3 2 3 9 10 1 2	1
300.0	10	R	2	3300	13.	14.4	1.6	4.	0.22	0.879	6.	0.34	2.056	2.934	3 2 3 9 10 1 2	1
500.0	10	R	2	3300	13.	14.9	2.1	4.	0.25	1.020	6.	0.41	2.490	3.510	3 2 3 9 10 1 2	1
1.5	10	R	2	3310	16.	0.0	-16.0	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
2.0	10	R	2	3310	15.	10.0	-6.0	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
5.0	10	R	2	3310	16.	11.1	-4.9	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
10.0	10	R	2	3310	16.	11.5	-4.5	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
50.0	10	R	2	3310	16.	12.4	-3.6	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
100.0	10	R	2	3310	16.	14.1	-1.9	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
300.0	10	R	2	3310	16.	14.7	-1.3	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
500.0	10	R	2	3310	16.	15.3	-0.7	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	1
1.5	10	R	2	3320	22.	0.0	-21.9	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
2.0	10	R	2	3320	22.	10.1	-11.8	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
5.0	10	R	2	3320	22.	11.1	-10.9	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
10.0	10	R	2	3320	22.	11.5	-10.4	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
50.0	10	R	2	3320	22.	12.4	-9.5	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
100.0	10	R	2	3320	22.	14.4	-7.5	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
300.0	10	R	2	3320	22.	15.1	-6.8	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
500.0	10	R	2	3320	22.	15.7	-6.2	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	1
1.5	10	R	3	3610	18.	0.0	-17.6	5.	0.00	0.000	6.	0.00	0.000	0.000	3 2 2 8 5 3 1	1
2.0	10	R	3	3610	18.	11.6	-6.0	5.	0.00	0.000	6.	0.00	0.000	0.000	3 2 2 8 5 3 1	1
5.0	10	R	3	3610	18.	14.1	-3.5	5.	0.08	0.373	6.	0.01	0.064	0.437	3 2 2 8 5 3 1	1
10.0	10	R	3	3610	18.	18.5	0.9	5.	1.00	4.800	6.	0.38	2.347	7.147	3 2 2 8 5 3 1	1
50.0	10	R	3	3610	18.	20.6	3.0	5.	1.00	4.800	6.	1.00	6.151	10.951	3 2 2 8 5 3 1	1
100.0	10	R	3	3610	18.	21.3	3.7	5.	1.00	4.800	6.	1.00	6.151	10.951	3 2 2 8 5 3 1	1
300.0	10	R	3	3610	18.	22.1	4.5	5.	1.00	4.800	6.	1.00	6.151	10.951	3 2 2 8 5 3 1	1
500.0	10	R	3	3610	18.	22.8	5.2	5.	1.00	4.800	6.	1.00	6.151	10.951	3 2 2 8 5 3 1	1
1.5	10	R	3	3610	20.	0.0	-20.0	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	1
2.0	10	R	3	3610	20.	11.6	-8.4	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	1
5.0	10	R	3	3610	20.	14.1	-5.9	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	1
10.0	10	R	3	3610	20.	18.5	-1.5	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	1
50.0	10	R	3	3610	20.	20.6	0.6	9.	0.11	0.950	7.	0.16	1.032	1.982	3 2 2 8 1 2 1	1
100.0	10	R	3	3610	20.	21.3	1.3	9.	0.20	1.741	7.	0.30	1.955	3.696	3 2 2 8 1 2 1	1
300.0	10	R	3	3610	20.	22.1	2.1	9.	0.25	2.224	7.	0.41	2.685	4.909	3 2 2 8 1 2 1	1
500.0	10	R	3	3610	20.	22.8	2.8	9.	0.29	2.536	7.	0.48	3.201	5.737	3 2 2 8 1 2 1	1

Exhibit 11

Sample Output

RETN PER.	BLG COD	C R	S A	STA-TION	ELEVA-TION	FLOOD HT(FT)	OVER 1-FLR	STRUCTURE $-VALUE	STRUCTURE %-DMG	STRUCTURE $-DAMAGE	CONTENT $-VALUE	CONTENT %-DMG	CONTENT $-DAMAGE	TOTAL $-DAMAGE	(TAX MAP KEY)							J #
100.0	25	C	1	1300	6.	0.0	-6.4	85.	0.00	0.000	60.	0.00	0.000	0.000	3	2	2	4	25	1	1	2
300.0	25	C	1	1300	6.	5.8	-0.6	85.	0.00	0.000	60.	0.00	0.000	0.000	3	2	2	4	25	1	1	2
500.0	25	C	1	1300	6.	6.7	0.3	85.	0.05	4.599	60.	0.01	0.378	4.977	3	2	2	4	25	1	1	2
100.0	25	C	1	1500	6.	0.0	-6.4	83.	0.00	0.000	20.	0.00	0.000	0.000	3	2	2	4	60	1	1	2
300.0	25	C	1	1500	6.	6.1	-0.3	83.	0.00	0.000	20.	0.00	0.000	0.000	3	2	2	4	60	1	1	2
500.0	25	C	1	1500	6.	6.9	0.5	83.	0.09	7.721	20.	0.04	0.769	8.490	3	2	2	4	60	1	1	2
100.0	25	C	1	2950	8.	0.0	-8.2	67.	0.00	0.000	36.	0.00	0.000	0.000	3	2	2	6	27	1	1	2
300.0	25	C	1	2950	8.	8.5	0.3	67.	0.05	3.609	36.	0.28	10.167	13.776	3	2	2	6	27	1	1	2
500.0	25	C	1	2950	8.	8.5	0.3	67.	0.05	3.609	36.	0.28	10.167	13.776	3	2	2	6	27	1	1	2
100.0	15	C	2	2960	6.	0.0	-6.3	26.	0.00	0.000	10.	0.00	0.000	0.000	3	2	3	8	29	1	1	2
300.0	15	C	2	2960	6.	8.5	2.2	26.	0.26	6.829	10.	0.85	8.152	14.981	3	2	3	8	29	1	1	2
500.0	15	C	2	2960	6.	8.6	2.3	26.	0.26	6.882	10.	0.86	8.216	15.098	3	2	3	8	29	1	1	2
100.0	15	C	2	2960	7.	0.0	-6.6	26.	0.00	0.000	54.	0.00	0.000	0.000	3	2	3	8	29	1	2	2
300.0	15	C	2	2960	7.	8.5	1.9	26.	0.24	6.395	54.	0.07	3.586	9.981	3	2	3	8	29	1	2	2
500.0	15	C	2	2960	7.	8.6	2.0	26.	0.25	6.468	54.	0.07	3.668	10.136	3	2	3	8	29	1	2	2
100.0	15	C	2	2970	8.	0.0	-7.5	8.	0.00	0.000	8.	0.00	0.000	0.000	3	2	3	8	28	1	4	2
300.0	15	C	2	2970	8.	8.5	1.0	8.	0.18	1.493	8.	0.18	1.402	2.895	3	2	3	8	28	1	4	2
500.0	15	C	2	2970	8.	8.6	1.1	8.	0.19	1.539	8.	0.21	1.606	3.145	3	2	3	8	28	1	4	2
100.0	25	C	2	2990	7.	0.0	-6.7	33.	0.00	0.000	38.	0.00	0.000	0.000	3	2	3	9	16	1	5	2
300.0	25	C	2	2990	7.	8.6	1.9	33.	0.24	7.933	38.	0.76	29.224	37.157	3	2	3	8	16	1	5	2
500.0	25	C	2	2990	7.	8.7	2.0	33.	0.25	8.274	38.	0.78	29.992	38.266	3	2	3	8	16	1	5	2
100.0	25	C	2	3000	8.	0.0	-7.9	33.	0.00	0.000	108.	0.00	0.000	0.000	3	2	3	8	16	1	4	2
300.0	25	C	2	3000	8.	8.6	0.7	33.	0.13	4.137	108.	0.55	59.322	63.459	3	2	3	8	16	1	4	2
500.0	25	C	2	3000	8.	8.8	0.9	33.	0.16	5.319	108.	0.64	69.454	74.773	3	2	3	8	16	1	4	2
100.0	25	C	2	3000	3.	0.0	-3.2	0.	0.00	0.000	50.	0.00	0.000	0.000	3	2	3	3	10	1	3	2
300.0	25	C	2	3000	3.	8.6	5.4	0.	0.00	0.000	50.	0.80	40.320	40.320	3	2	3	3	10	1	3	2
500.0	25	C	2	3000	3.	8.8	5.6	0.	0.00	0.000	50.	0.80	40.320	40.320	3	2	3	3	10	1	3	2
100.0	15	C	2	3000	10.	0.0	-10.2	50.	0.00	0.000	22.	0.00	0.000	0.000	3	2	3	3	12	1	1	2
300.0	15	C	2	3000	10.	8.6	-1.6	50.	0.00	0.000	22.	0.00	0.000	0.000	3	2	3	3	12	1	1	2
500.0	15	C	2	3000	10.	8.8	-1.4	50.	0.00	0.000	22.	0.00	0.000	0.000	3	2	3	3	12	1	1	2
100.0	20	C	2	3000	8.	0.0	-8.0	3.	0.00	0.000	34.	0.00	0.000	0.000	3	2	3	9	14	1	1	2
300.0	20	C	2	3000	8.	8.6	0.6	3.	0.11	0.324	34.	0.24	8.117	6.441	3	2	3	9	14	1	1	2
500.0	20	C	2	3000	8.	8.8	0.8	3.	0.14	0.432	34.	0.34	11.258	11.690	3	2	3	9	14	1	1	2
100.0	15	C	2	3000	10.	0.0	-9.6	77.	0.00	0.000	84.	0.00	0.000	0.000	3	2	3	3	10	1	2	2
300.0	15	C	2	3000	10.	8.6	-1.0	77.	0.00	0.000	84.	0.00	0.000	0.000	3	2	3	3	10	1	2	2
500.0	15	C	2	3000	10.	8.8	-0.8	77.	0.00	0.000	84.	0.00	0.000	0.000	3	2	3	3	10	1	2	2
100.0	15	C	2	3000	10.	0.0	-9.9	50.	0.00	0.000	120.	0.00	0.000	0.000	3	2	3	3	11	1	1	2
300.0	15	C	2	3000	10.	8.6	-1.3	50.	0.00	0.000	120.	0.00	0.000	0.000	3	2	3	3	11	1	1	2
500.0	15	C	2	3000	10.	8.8	-1.1	50.	0.00	0.000	120.	0.00	0.000	0.000	3	2	3	3	11	1	1	2
100.0	25	C	2	3010	7.	0.0	-7.0	33.	0.00	0.000	24.	0.00	0.000	0.000	3	2	3	8	16	1	2	2
300.0	25	C	2	3010	7.	8.7	1.7	33.	0.23	7.611	24.	0.60	14.306	21.917	3	2	3	8	16	1	2	2
500.0	25	C	2	3010	7.	8.9	1.9	33.	0.24	7.978	24.	0.64	15.324	23.302	3	2	3	8	16	1	2	2
100.0	25	C	2	3010	8.	0.0	-7.9	33.	0.00	0.000	5.	0.00	0.000	0.000	3	2	3	8	16	1	3	2
300.0	25	C	2	3010	8.	8.7	0.8	33.	0.15	4.964	5.	0.18	0.991	5.955	3	2	3	8	16	1	3	2
500.0	25	C	2	3010	8.	8.9	1.0	33.	0.18	5.910	5.	0.22	1.200	7.110	3	2	3	8	16	1	3	2
100.0	15	C	2	3010	10.	0.0	-10.4	13.	0.00	0.000	54.	0.00	0.000	0.000	3	2	3	3	14	1	2	2
300.0	15	C	2	3010	10.	8.7	-1.7	13.	0.00	0.000	54.	0.00	0.000	0.000	3	2	3	3	14	1	2	2
500.0	15	C	2	3010	10.	8.9	-1.5	13.	0.00	0.000	54.	0.00	0.000	0.000	3	2	3	3	14	1	2	2
100.0	15	C	2	3010	10.	0.0	-10.3	21.	0.00	0.000	611.	0.00	0.000	0.000	3	2	3	3	13	1	1	2
300.0	15	C	2	3010	10.	8.7	-1.6	21.	0.00	0.000	611.	0.00	0.000	0.000	3	2	3	3	13	1	1	2

Exhibit 11

Sample Output

RETN PER.	BLG COD	C R	S A	STA-TION	ELEVA-TION	FLOOD HT(FT)	OVER 1-FLR	STRUCTURE $-VALUE	STRUCTURE %-DMG	STRUCTURE $-DAMAGE	CONTENT $-VALUE	CONTENT %-DMG	CONTENT $-DAMAGE	TOTAL $-DAMAGE	(TAX MAP KEY)	#
300.0	15	C	2	3040	10.	9.2	-0.6	24.	0.00	0.000	12.	0.00	0.000	0.000	3 2 3 7 50 1 1	2
500.0	15	C	2	3040	10.	9.2	-0.6	24.	0.00	0.000	12.	0.00	0.000	0.000	3 2 3 7 50 1 1	2
100.0	15	C	2	3040	10.	0.0	-9.6	23.	0.00	0.000	132.	0.00	0.000	0.000	3 2 3 7 50 1 2	2
300.0	15	C	2	3040	10.	9.2	-0.4	23.	0.00	0.000	132.	0.00	0.000	0.000	3 2 3 7 50 1 2	2
500.0	15	C	2	3040	10.	9.2	-0.4	23.	0.00	0.000	132.	0.00	0.000	0.000	3 2 3 7 50 1 2	2
100.0	25	C	2	3040	7.	0.0	-7.3	80.	0.00	0.000	42.	0.00	0.000	0.000	3 2 3 8 12 2 1	2
300.0	25	C	2	3040	7.	9.2	1.9	80.	0.24	19.216	42.	0.31	13.212	32.428	3 2 3 8 12 2 1	2
500.0	25	C	2	3040	7.	9.2	1.9	80.	0.24	19.440	42.	0.32	13.380	32.820	3 2 3 8 12 2 1	2
100.0	15	C	2	3050	11.	0.0	-11.1	77.	0.00	0.000	28.	0.00	0.000	0.000	3 2 3 3 10 1 1	2
300.0	15	C	2	3050	11.	9.3	-1.8	77.	0.00	0.000	28.	0.00	0.000	0.000	3 2 3 3 10 1 1	2
500.0	15	C	2	3050	11.	9.3	-1.8	77.	0.00	0.000	28.	0.00	0.000	0.000	3 2 3 3 10 1 1	2
100.0	15	C	2	3050	10.	0.0	-9.5	120.	0.00	0.000	0.	0.00	0.000	0.000	3 2 3 7 12 1 1	2
300.0	15	C	2	3050	10.	9.3	-0.2	120.	0.00	0.000	0.	0.00	0.000	0.000	3 2 3 7 12 1 1	2
500.0	15	C	2	3050	10.	9.3	-0.2	120.	0.00	0.000	0.	0.00	0.000	0.000	3 2 3 7 12 1 1	2
100.0	20	C	2	3050	13.	0.0	-13.1	8.	0.00	0.000	0.	0.00	0.000	0.000	3 2 3 7 12 2 1	2
300.0	20	C	2	3050	13.	9.3	-3.8	8.	0.00	0.000	0.	0.00	0.000	0.000	3 2 3 7 12 2 1	2
500.0	20	C	2	3050	13.	9.3	-3.8	8.	0.00	0.000	0.	0.00	0.000	0.000	3 2 3 7 12 2 1	2
100.0	15	C	2	3060	9.	0.0	-9.3	13.	0.00	0.000	85.	0.00	0.000	0.000	3 2 3 7 15 1 2	2
300.0	15	C	2	3060	9.	9.4	0.1	13.	0.01	0.140	85.	0.00	0.144	0.284	3 2 3 7 15 1 2	2
500.0	15	C	2	3060	9.	9.3	0.0	13.	0.01	0.094	85.	0.00	0.096	0.190	3 2 3 7 15 1 2	2
100.0	15	C	2	3060	10.	0.0	-9.8	13.	0.00	0.000	42.	0.00	0.000	0.000	3 2 3 7 15 1 1	2
300.0	15	C	2	3060	10.	9.4	-0.4	13.	0.00	0.000	42.	0.00	0.000	0.000	3 2 3 7 15 1 1	2
500.0	15	C	2	3060	10.	9.3	-0.5	13.	0.00	0.000	42.	0.00	0.000	0.000	3 2 3 7 15 1 1	2
100.0	25	C	2	3070	8.	0.0	-8.0	25.	0.00	0.000	54.	0.00	0.000	0.000	3 2 3 8 18 2 1	2
300.0	25	C	2	3070	8.	9.4	1.4	25.	0.21	5.165	54.	0.48	26.136	31.301	3 2 3 8 18 2 1	2
500.0	25	C	2	3070	8.	9.4	1.4	25.	0.21	5.096	54.	0.48	25.704	30.800	3 2 3 8 18 2 1	2
100.0	10	R	2	3230	13.	0.0	-12.8	1.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 5 2 1	2
300.0	10	R	2	3230	13.	9.8	-3.0	1.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 5 2 1	2
500.0	10	R	2	3230	13.	10.4	-2.4	1.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 5 2 1	2
100.0	10	R	2	3270	16.	0.0	-16.0	7.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 6 2 1	2
300.0	10	R	2	3270	16.	10.1	-5.9	7.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 6 2 1	2
500.0	10	R	2	3270	16.	10.6	-5.4	7.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 6 2 1	2
100.0	10	R	2	3280	13.	0.0	-12.9	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	2
300.0	10	R	2	3280	13.	10.2	-2.6	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	2
500.0	10	R	2	3280	13.	10.6	-2.2	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 1	2
100.0	10	R	2	3300	13.	0.0	-12.8	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	2
300.0	10	R	2	3300	13.	10.6	-2.2	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	2
500.0	10	R	2	3300	13.	10.7	-2.1	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 10 1 2	2
100.0	10	R	2	3310	16.	0.0	-16.0	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	2
300.0	10	R	2	3310	16.	10.7	-5.3	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	2
500.0	10	R	2	3310	16.	10.7	-5.3	4.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 9 7 3 1	2
100.0	10	R	2	3320	22.	0.0	-21.9	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	2
300.0	10	R	2	3320	22.	10.9	-11.0	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	2
500.0	10	R	2	3320	22.	10.7	-11.2	2.	0.00	0.000	6.	0.00	0.000	0.000	3 2 3 7 32 2 1	2
100.0	10	R	3	3610	18.	0.0	-17.6	5.	0.00	0.000	6.	0.00	0.000	0.000	3 2 2 8 5 3 1	2
300.0	10	R	3	3610	18.	12.5	-5.1	5.	0.00	0.000	6.	0.00	0.000	0.000	3 2 2 8 5 3 1	2
500.0	10	R	3	3610	18.	13.6	-4.0	5.	0.00	0.000	6.	0.00	0.000	0.000	3 2 2 8 5 3 1	2
100.0	10	R	3	3610	20.	0.0	-20.0	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	2
300.0	10	R	3	3610	20.	12.5	-7.5	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	2
500.0	10	R	3	3610	20.	13.6	-6.4	9.	0.00	0.000	7.	0.00	0.000	0.000	3 2 2 8 1 2 1	2

Exhibit 11

Sample Output

SUBAREA 1
DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR
RESIDENTIAL AND NON-RESIDENTIAL STRUCTURES AND CONTENTS
(DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	0.000	0.000	0.000
5.0	27.843	12.930	40.773
10.0	46.465	17.286	63.751
50.0	66.315	45.196	111.511
100.0	70.176	52.796	122.973
300.0	75.695	64.341	140.036
500.0	80.082	71.302	151.384

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	3.609	10.167	13.776
500.0	15.929	11.314	27.243

AVERAGE ANNUAL BENEFITS

CONDITION	STRUCTURES	AVERAGE ANNUAL DAMAGES CONTENTS	TOTAL
W/O PROJECT	13.836	7.063	20.899
WITH PROJECT	0.057	0.071	0.128
	--------------	--------------	--------------
BENEFIT	13.779	6.992	20.771

Exhibit 11

SUBAREA 2
DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR
RESIDENTIAL AND NON-RESIDENTIAL STRUCTURES AND CONTENTS
(DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	74.618	267.075	341.693
5.0	129.697	512.137	641.835
10.0	163.668	629.712	793.380
50.0	359.520	944.059	1303.579
100.0	446.824	1073.538	1520.362
300.0	547.847	1228.632	1776.478
500.0	610.706	1323.399	1934.106

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	107.464	420.009	527.473
500.0	112.881	446.571	559.452

AVERAGE ANNUAL BENEFITS

	AVERAGE ANNUAL DAMAGES		
CONDITION	STRUCTURES	CONTENTS	TOTAL
W/O PROJECT	81.802	281.291	363.094
WITH PROJECT	0.731	2.871	3.602
	--------------	--------------	--------------
BENEFIT	81.071	278.420	359.492

Exhibit 11

Sample Output

SUBAREA 5

DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR RESIDENTIAL AND NON-RESIDENTIAL STRUCTURES AND CONTENTS (DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	3.537	0.454	3.992
5.0	22.371	4.732	27.104
10.0	32.516	32.381	64.899
50.0	38.058	56.241	94.299
100.0	39.787	60.708	100.493
300.0	40.988	64.174	105.161
500.0	41.833	66.562	108.392

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	18.791	8.008	26.799
500.0	7.114	0.939	8.051

AVERAGE ANNUAL BENEFITS

	AVERAGE ANNUAL DAMAGES		
CONDITION	STRUCTURES	CONTENTS	TOTAL
W/O PROJECT	10.546	7.438	17.983
WITH PROJECT	0.094	0.035	0.129
	---------------	---------------	---------------
BENEFIT	10.451	7.403	17.855

Exhibit 11

SUBAREA 4
DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR
RESIDENTIAL AND NON-RESIDENTIAL STRUCTURES AND CONTENTS
(DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	88.294	47.560	135.854
5.0	92.820	49.793	142.613
10.0	92.820	49.793	142.613
50.0	92.820	49.793	142.613
100.0	92.820	49.793	142.613
300.0	92.820	49.793	142.613
500.0	92.820	49.793	142.613

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	92.820	49.793	142.613
500.0	92.820	49.793	142.613

AVERAGE ANNUAL BENEFITS

	AVERAGE ANNUAL DAMAGES		
CONDITION	STRUCTURES	CONTENTS	TOTAL
W/O PROJECT	53.089	28.525	81.614
WITH PROJECT	0.619	0.332	0.951
BENEFIT	52.470	28.193	80.663

Exhibit 11

DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR
RESIDENTIAL STRUCTURES AND CONTENTS
(DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	91.831	48.014	139.846
5.0	115.191	54.525	169.717
10.0	125.336	82.174	207.512
50.0	130.878	106.034	236.912
100.0	133.471	112.391	245.865
300.0	135.287	117.336	252.621
500.0	136.572	121.227	257.797

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	111.611	57.801	169.412
500.0	99.934	50.732	150.664

AVERAGE ANNUAL BENEFITS

	AVERAGE ANNUAL DAMAGES		
CONDITION	STRUCTURES	CONTENTS	TOTAL
W/O PROJECT	63.653	36.005	99.657
WITH PROJECT	0.713	0.366	1.079
	---------------	---------------	---------------
BENEFIT	62.940	35.638	98.578

Exhibit 11

DAMAGE-FREQUENCY DATA AND AVERAGE ANNUAL BENEFITS FOR
NON-RESIDENTIAL STRUCTURES AND CONTENTS
(DAMAGE ESTIMATES IN $1,000'S)

DAMAGES WITHOUT PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
1.5	0.000	0.000	0.000
2.0	74.618	267.075	341.693
5.0	157.540	525.067	682.608
10.0	210.133	646.998	857.131
50.0	425.835	989.255	1415.090
100.0	516.136	1124.444	1640.561
300.0	622.063	1289.604	1911.667
500.0	638.869	1389.829	2078.698

DAMAGES WITH PROJECT

RECURRENCE INTERVAL	STRUCTURE DAMAGE	CONTENT DAMAGE	TOTAL DAMAGE
100.0	0.000	0.000	0.000
300.0	111.073	430.176	541.249
500.0	128.810	457.885	586.695

AVERAGE ANNUAL BENEFITS

	AVERAGE ANNUAL DAMAGES		
CONDITION	STRUCTURES	CONTENTS	TOTAL
W/O PROJECT	95.620	288.312	383.932
WITH PROJECT	0.788	2.942	3.730
	--------------	--------------	--------------
BENEFIT	94.832	285.370	380.202

Exhibit 11

Sample Output

PROJECT -- DISASTER STREAM, ANYWHERE, U.S.A.
PROPERTY INVENTORY INPUT FILE NAME -- PITEST

DAMAGABLE PROPERTY INVENTORY SUMMARY

	NUMBER OF DAMAGE UNITS			NUMBER OF STRUCTURES		
DAMAGE ZONE	RESI-DENTIAL	NONRESI-DENTIAL	TOTAL	RESI-DENTIAL	NONRESI-DENTIAL	TOTAL
LOW VELOCITY	23	42	65	19	25	44
HIGH VELOCITY	7	0	7	7	0	7
TOTAL	30	42	72	26	25	51

Exhibit 11

REGIONAL DEVELOPMENT BENEFIT ANALYSES FOR THE COOSA RIVER NAVIGATION PROJECT

William F. Hearrean, Chief, Socio/Economics Branch
Mobile District

REGIONAL DEVELOPMENT BENEFIT ANALYSES FOR THE
COOSA RIVER NAVIGATION PROJECT

The purpose of this report is to estimate the regional development benefits (RDB's) associated with construction and operation of the Coosa River Navigation Project. Three entirely different methods have been used by contractors to determine RDB's. Since methodologies for evaluating these benefits from navigation projects are not currently developed extensively, this approach was necessary for verification. One method analyzed RDB's in three regions, and did not include the United States, while the other two methods analyzed RDB's in four regions including the total United States. These regions are shown of Figure 1.

The entire report from each of the three contractors is included as attachments to Volume 8 of the Coosa River Channel General Design Memorandum. These attachments provide details of each of the methodologies used. The United States Army Engineer Institute of Water Resources (IWR) is developing a User's Manual and models which will provide in-house capability for the Corps to produce estimates of RDB's for other navigation projects.

Regional Development Benefits are defined as changes in personal income, either plus or minus, brought about by construction and operation of the Coosa River Navigation Channel. The same basic data were used as input for each procedure. These data included a construction schedule by year, base year, and projected tonnages of commodities receiving savings in transportation costs and savings per ton for each commodity involved. Benefits were analyzed for four regions making up the entire United States. These Regions include the 10-county Coosa Region in Alabama; the Gulf Coast Region including counties in Mississippi, Alabama, and Florida; the remainder of all counties in Alabama; and the remainder of all States in the United States. These evaluations are based on changes in personal income and employment from construction expenditures, transportation savings, losses in hydroelectric power, and losses in rail revenue.

REGIONAL DEFINITIONS USED FOR THE COOSA RIVER NAVIGATION PROJECT EVALUATION

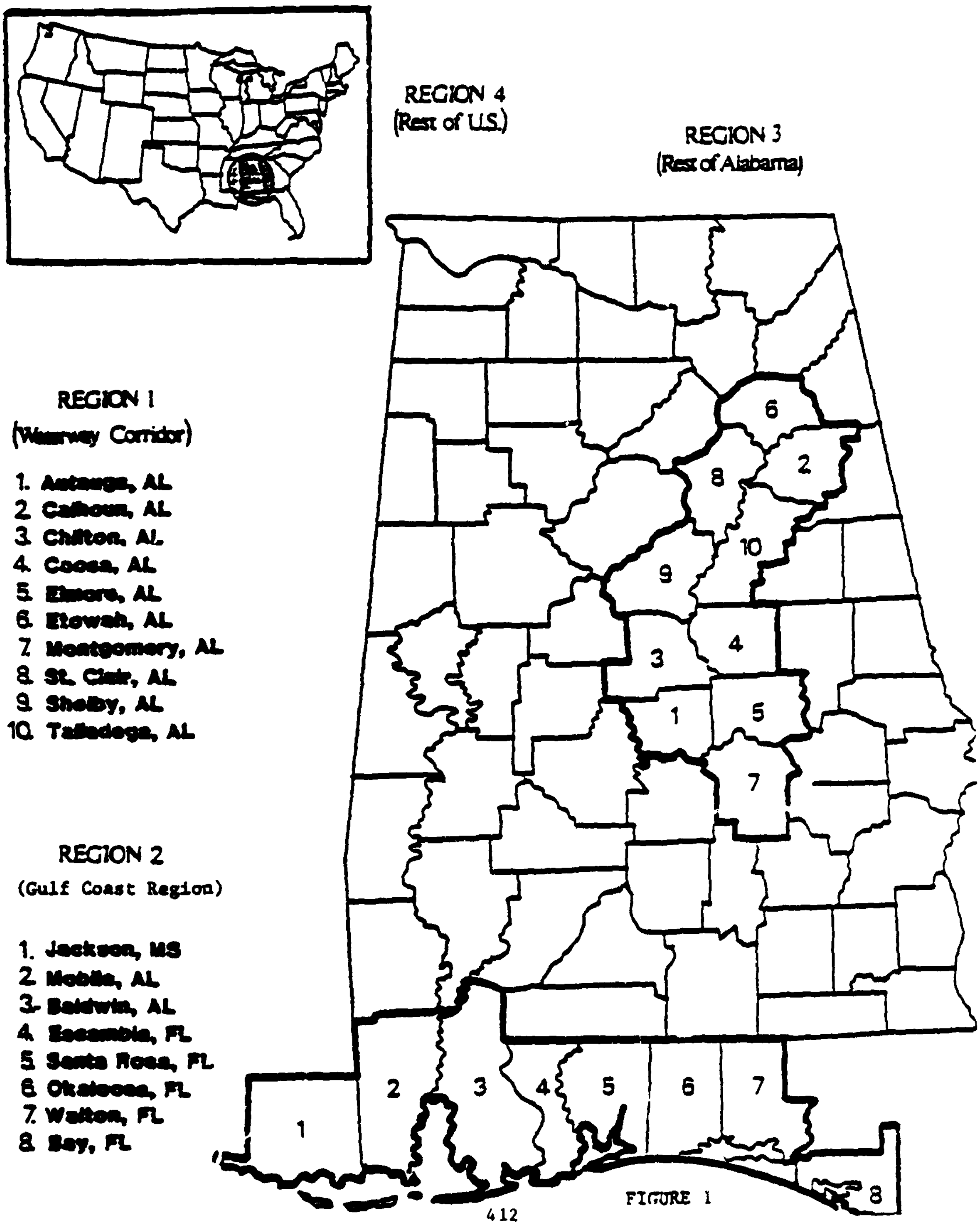


FIGURE 1

Methodologies

Industrial Location Model Analysis (ILMA). This method was developed by Plantec Corporation and bases the analysis on two major equally important theses. One, the major transportation impact of the waterway is to connect the Coosa Valley with economic areas characterized by higher projected growth rates than would be achieved in the Coosa Valley without the waterway. The key analytical procedure is to calculate the differential growth and to convert it into changes in output, income and employment. Second, the ability of the region to realize this potential added growth due to the waterway, is in its ability to compete. This is measured by location analysis which systematically evaluates the availability and costs of labor force, infrastructure, and many other elements of siting required to analyze economic activity.

The approach used by Plantec generates first round, or direct, impacts which are increased by multipliers to account for indirect impacts. The multipliers were estimated by the Bureau of Economic Analysis, United States Department of Commerce with the RIMS input-output model calibrated for the 10-county Coosa Valley area. Estimates of gross output, personal income and employment were developed for Region I (Coosa Valley), Region II (Primary-Gulf Counties) and Region III (Rest of Alabama). These evaluations are based on impacts from construction expenditures, transportation savings, losses of hydroelectric power, and losses in rail revenue.

The method also generated two hypothetical, but possible, scenarios which reflect moderate and maximum development of river-oriented industry. These benefits are not included in the RDB's since they are not consistent with the results of the other two methodologies. The Coosa Valley has a significant opportunity to increase and modernize its economic base as a result of tailoring its economic development strategy on sites with access to the Coosa River Navigation Project. The moderate scenario assumes two major riverside industrial parks near Lincoln-Pell City (on the Interstate 20 and Southern Railroad between Birmingham and Atlanta) and Childersburg, Alabama (near the current site under development by the city of Childersburg and Talladega County). The industrial parks would be completed within 25 years after the waterway is completed. The maximum scenario accelerates development to be completed in 10 years and introduces

an additional industrial development site at Gadsden, Alabama. The analysis does not include all potential development sites, but does focus on those with the most likely, early potential.

Multiregional Variable Input-Output Model (MRVIO)[1/]. This model was developed by Professors Chong and Chung Liew at the University of Oklahoma and was used to determine economic changes resulting from construction and operation of the Coosa River Project. The MRVIO evaluates the impact of reductions in transportation costs through the effects on trade flows and the effects on the use of lower cost inputs to the production process. Construction impacts are evaluated through the effects on expenditures for items associated with construction. The model was calibrated for four regions (covering the United States) and 31 industry sectors. It provides equilibrium estimates of the impacts of construction expenditures, transportation savings and lowered hydropower output on gross output, personal income, and employment for each industry in each region. The primary technical advantage of the MRVIO is that is simultaneously estimates changes in trade flows and input substitution in response to changes in transportation costs.

[1/] Liew, C. K., and Liew, C. J., "Use of a Multiregional Variable Input-Output Model to Analyze Economic Impact of Transportation Costs," Transportation Research Record 747, 1980b.

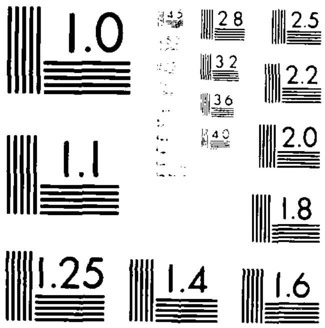
Liew, C. K., and Liew, C. J., The McClellan-Kerr Waterway and Region Economic Development, IWR, The Army Corps of Engineers, 1981a.

Liew, C. K., and Liew, C. J., The Economic Effects of a Proposed Water Shortage on Oklahoma Economy, A contract report Oklahoma Water Resources Board, 1981b.

Liew, C. K., and Liew, C. J., "Energy Crisis and Interregional Trade Flows," 1980 Proceedings of the Business and Economic Section of the American Statistical Association Meeting, 1981c.

AD-A136 867 PROCEEDINGS: ECONOMIC AND SOCIAL ANALYSIS WORKSHOP HELD AT ST LOUIS MISSO..(U) ARMY ENGINEER INST FOR WATER RESOURCES FORT BELVOIR VA L G ANTLE OCT 83 IWR-83-P-40 5/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU [illegible] STANDARDS [illegible]

Multiregional - Multi-Industry Model (MRMI). This model was developed by Professor Curtis Harris at the University of Maryland[2] and used by Urban Systems in the evaluation of RDB's for the Coosa River Project. The model has been successfully utilized (1) to compare program alternatives to complete the United States Interstate Highway System, (2) to evaluate a segment of the Interstate Highway System, and (3) to evaluate the impact of port deepening options.

The MRMI model is an econometric model based on a large number of industry sectors and founded on county level data. It is, therefore, unusually flexible in determining impacts by small regions and detailed industry sector and is a national model. The MRMI operates in a recursive mode using estimates for time "t" to generate estimates fo time "t + n," to generate overall national estimates which are consistent with independent forecasts such as the Inforum model at the University of Maryland[3] and OBERS projections from Bureau of Economic Analysis, Department of Commerce. The MRMI moves new investment to the region which has the highest estimated profit available to that activity. The rate of adjustment in new investment is buffered by the recursive model, and thus provides a more realistic pacing in the change of output, income and employment than equilibrium models. Input to the MRMI is construction expenditures, transportation savings, and losses of hydropower.

[2] See, for example, Curtis C. Harris, Jr., The Urban Economies, 1985: A Multiregional, Multi-Industry Forecasting Model. Lexington, MA: Lexington Books, 1973; Curtis C. Harris, Jr., and Frank E. Hopkins, Locational Analysis: An Inter-regional Econometric Model of Agriculture, Mining, Manufacturing and Services. Lexington, MA: Lexington Books, 1972; Curtis C. Harris, Jr., Regional Economic Effects of Alternative Highway Systems. Cambridge, MA: Ballinger Publishing Co., 1974; Curtis C. Harris, Jr., "New Developments and Extensions of the Multiregional Multi-Industry Forecasting Model", Journal of Regional Science, 20:159-172, 1980.

[3] See Clopper Almon, Jr., et al., 1985: Interindustry Forecasts of the American Economy. Lexington, MA: Lexington Books, 1974.

The MRMI model generated estimates of changes in regional output, personal income, and employment for Regions I, II, III, and IV (rest of the United States). The Urban Systems estimates are potentially valuable in illustrating the dynamics of economic development. Evidence of relative price increases is included in labor or other factors. Decreases in the rate of unemployment and the other economic cost elements act to decrease competitive investment sectors in the same region and in other regions.

Summary

The average annual equivalent benefits (personal income) as determined by each method are shown on the two attached tables. Some of these benefits contain transfers from other regions. Following the guidelines of the Water Resource Council's Principles and Standards, these benefits are not included in the National Economic Development analysis for project benefits. The MRMI method resulted in some negative benefits in some regions, whereas the two other methods report net positive benefits in all regional analyzed. Obviously, the MRMI method results suggest net transfers from certain regions. One way of presenting the national effects of the Coosa Project would be to exactly follow the existing guidance to present only positive gains in each region and account for all transfers in the transfer column. The other way is to present each method's estimates for each region, sum the results and use the transfer column entry as an adjustment to reflect unidentified transfers. The attached tables shows the results of both procedures.

The impacts on employment and income resulting from each procedure are shown on Figures 2 through 6. Figures 3 and 4 show the impacts resulting from the moderate and maximum development of river-oriented industry as determined by Plantec. Each figure shows impacts only and does not include any growth that would occur without construction of the Coosa River Navigation Project.

TABLE A

SUMMARY OF AVERAGE ANNUAL EQUIVALENT BENEFITS
REGIONAL DEVELOPMENT - COOSA RIVER NAVIGATION PROJECT
(Millions 1981 $ at 2-5/8%)

METHOD	REGION I COOSA REGION	REGION II GULF COAST REGION	REGION III REMAINDER OF ALABAMA	REGION IV REMAINDER OF US	TOTALS	TRANSFERS[2/]	NED
ILMA	$57.0	$ 0.7	$ 1.5	$ 0[1/]	$59.2	$-59.2	$ 0
MRVIO	17.2	5.4	4.4	22.7	49.7	-49.7	0
MRMI[3/]	63.2	15.8	17.0	0.1	96.1	-96.1	0
MRMI[4/]	63.2	14.9	12.8	-66.8	24.1	-24.1	0

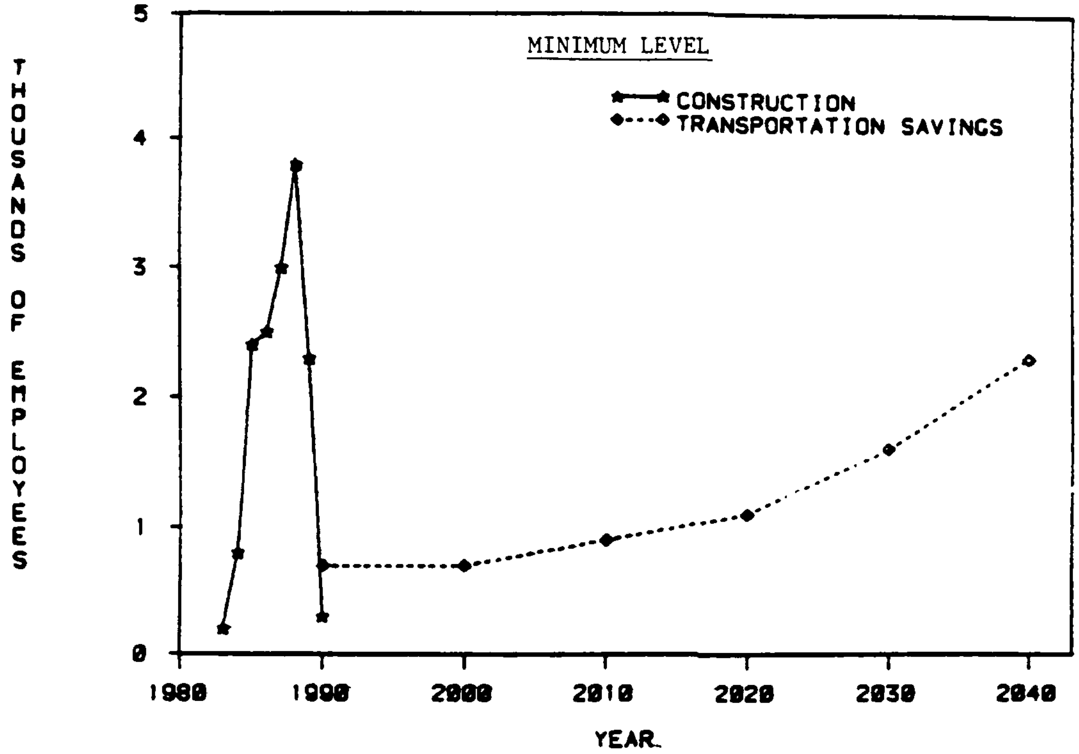
TABLE B

SUMMARY OF AVERAGE ANNUAL EQUIVALENT BENEFITS
REGIONAL DEVELOPMENT - COOSA RIVER NAVIGATION PROJECT
(Millions 1981 $ at 7-5/8%)

METHOD	COOSA REGION	GULF COAST REGION	REMAINDER OF ALABAMA	REMAINDER OF US	TOTALS	TRANSFERS	NED
ILMA	$ 58.9	$ 1.7	$ 8.4	$ 0[1/]	$ 69.0	$- 69.0	$ 0
MRVIO	29.5	5.5	9.5	47.0	91.5	- 91.5	0
MRMI[3/]	127.2	6.4	5.3	0.4	139.3	139.3	0
MRMI[4/]	127.2	4.9	-3.7	-75.0	53.4	- 53.4	0

[1/] Not evaluated.
[2/] RDB's represent transfers from other regions, therefore effects to the national account must equal zero.
[3/] All negative values are considered to be zeros.
[4/] All negative values are considered to be minus.

ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-EMPLOYMENT (BASED ON ILMA METHOD-PLANTEC



ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ
COOSA VALLEY REGION-INCOME (BASED ON ILMA METHOD-PLANTEC)

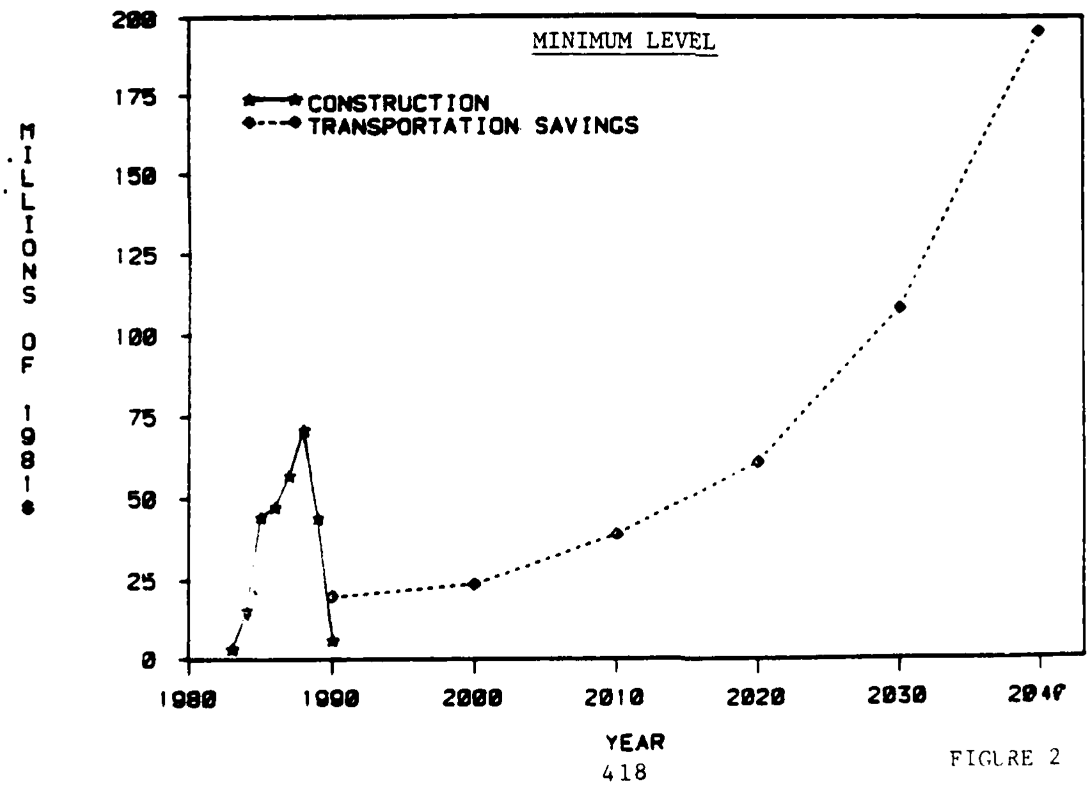
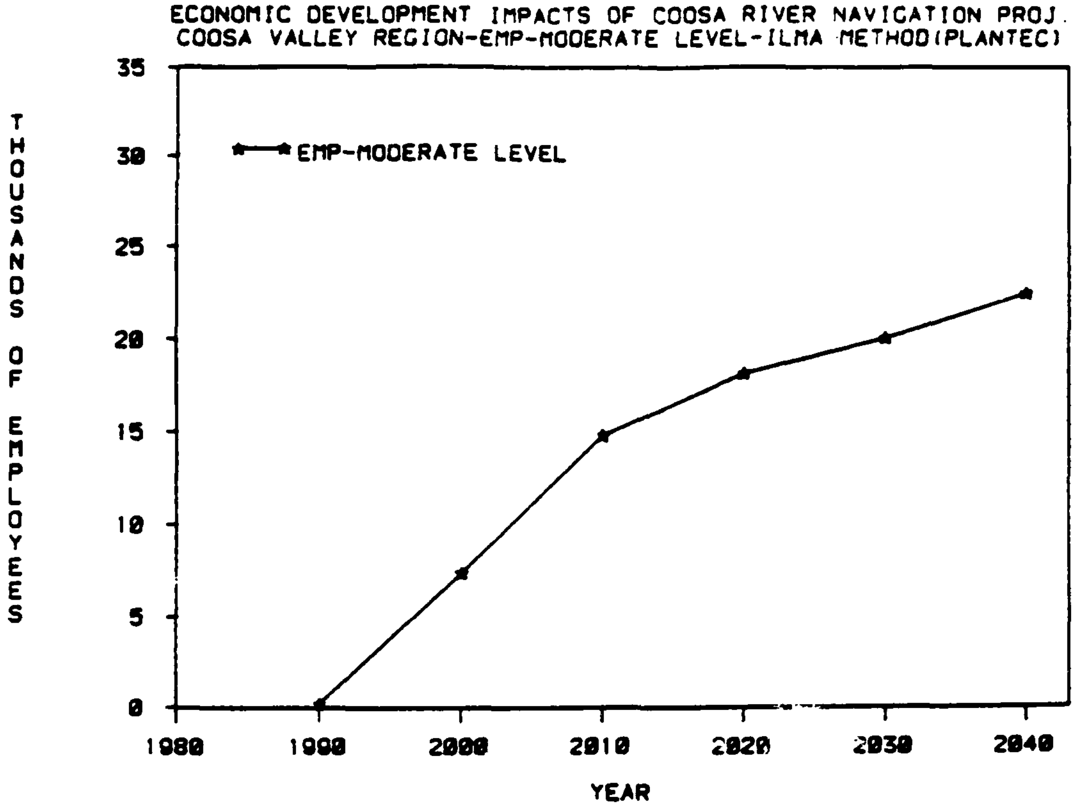
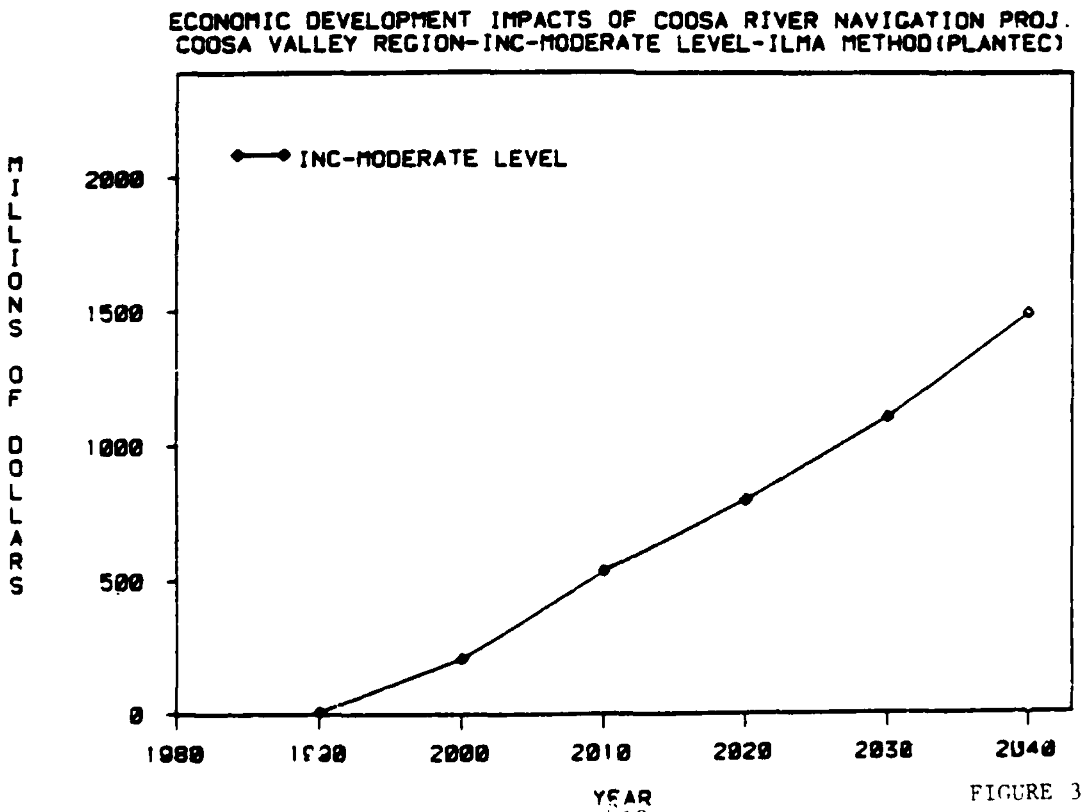


FIGURE 2

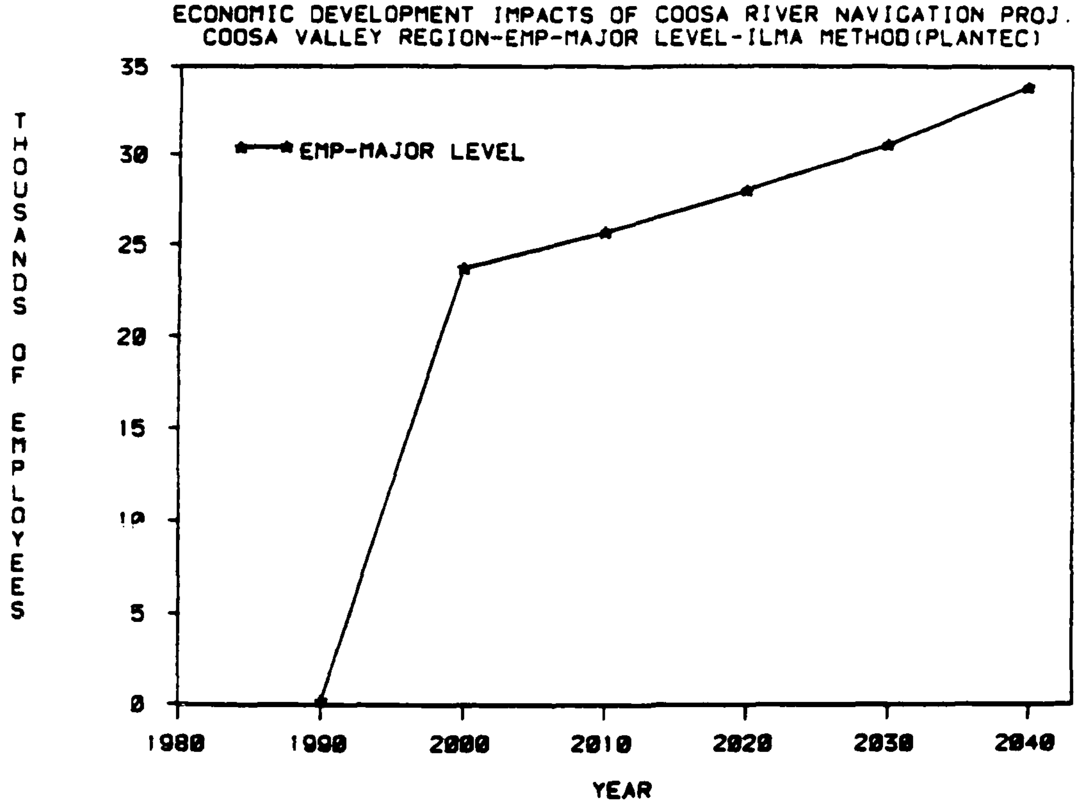


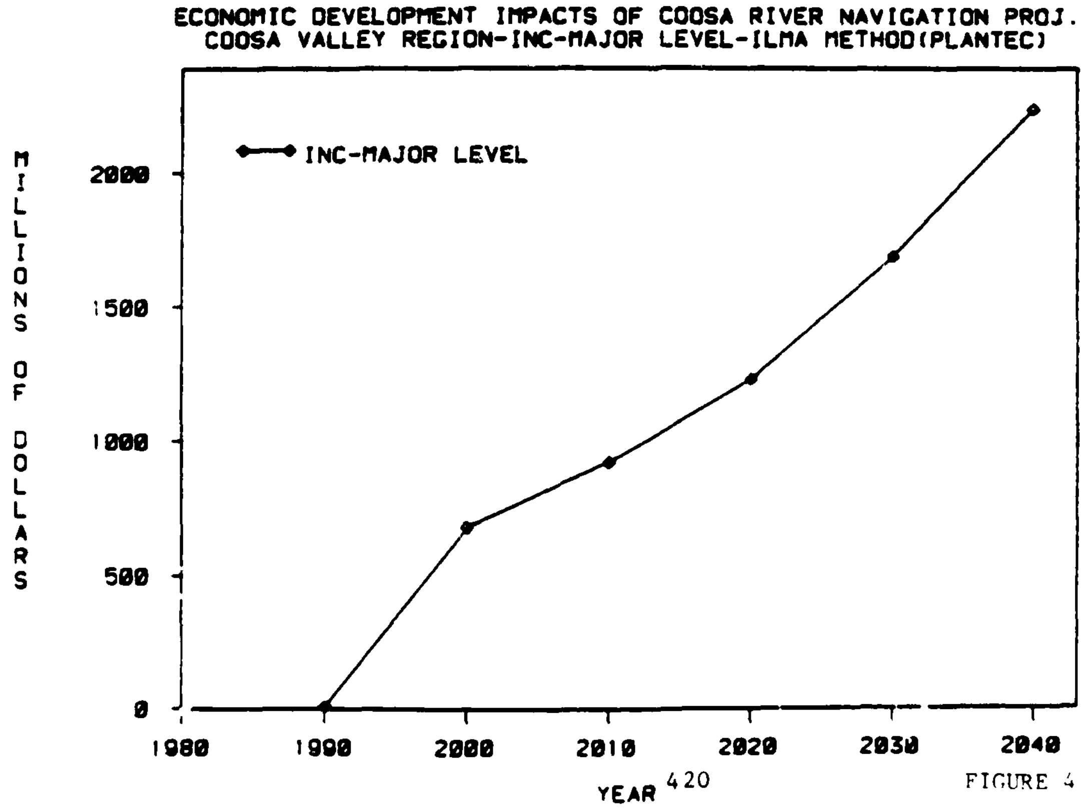
ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-EMP-MODERATE LEVEL-ILMA METHOD(PLANTEC)
EMP-MODERATE LEVEL
THOUSANDS OF EMPLOYEES
35
30
25
20
15
10
5
0
1980
1990
2000
2010
2020
2030
2040
YEAR



ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-INC-MODERATE LEVEL-ILMA METHOD(PLANTEC)
INC-MODERATE LEVEL
MILLIONS OF DOLLARS
2000
1500
1000
500
0
1980
1990
2000
2010
2020
2030
2040
YEAR

FIGURE 3

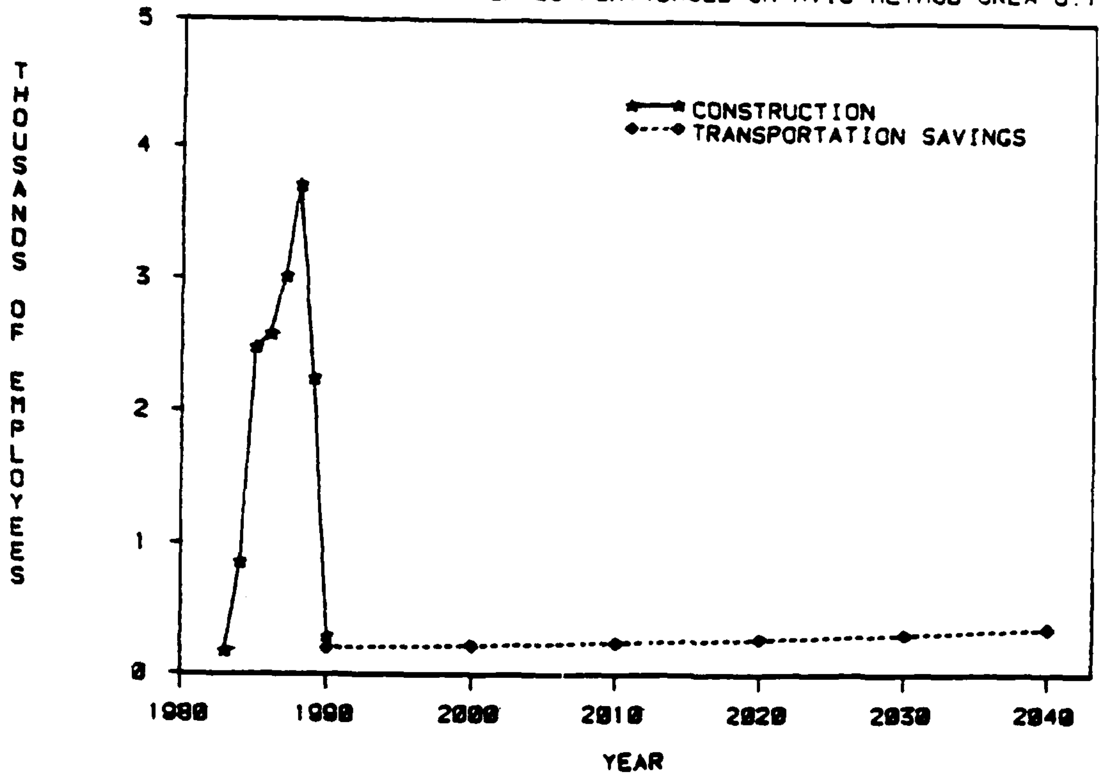

ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-EMP-MAJOR LEVEL-ILMA METHOD(PLANTEC)
EMP-MAJOR LEVEL
THOUSANDS OF EMPLOYEES
35
30
25
20
15
10
5
0
1980
1990
2000
2010
2020
2030
2040
YEAR


ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-INC-MAJOR LEVEL-ILMA METHOD(PLANTEC)
INC-MAJOR LEVEL
MILLIONS OF DOLLARS
2000
1500
1000
500
0
1980
1990
2000
2010
2020
2030
2040
YEAR

420

FIGURE 4

ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-EMPLOYMENT (BASED ON MVIO METHOD-OKLA U.)



ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-INCOME (BASED ON MVIO METHOD-OKLA U.)

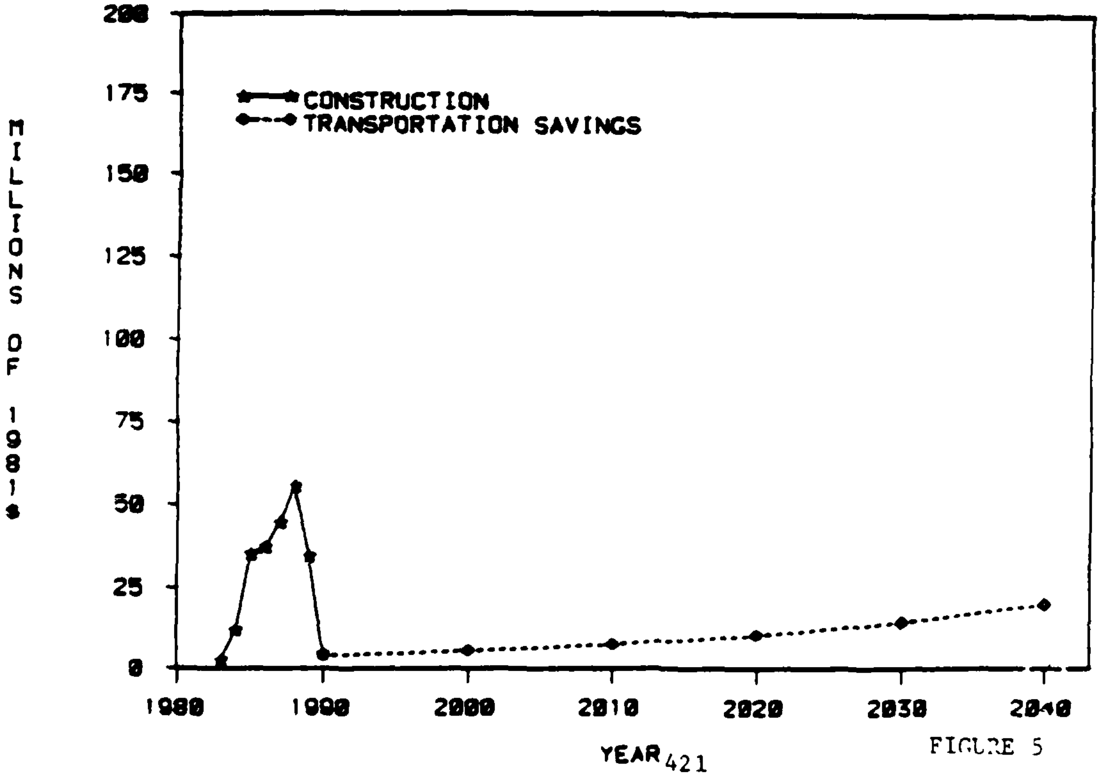
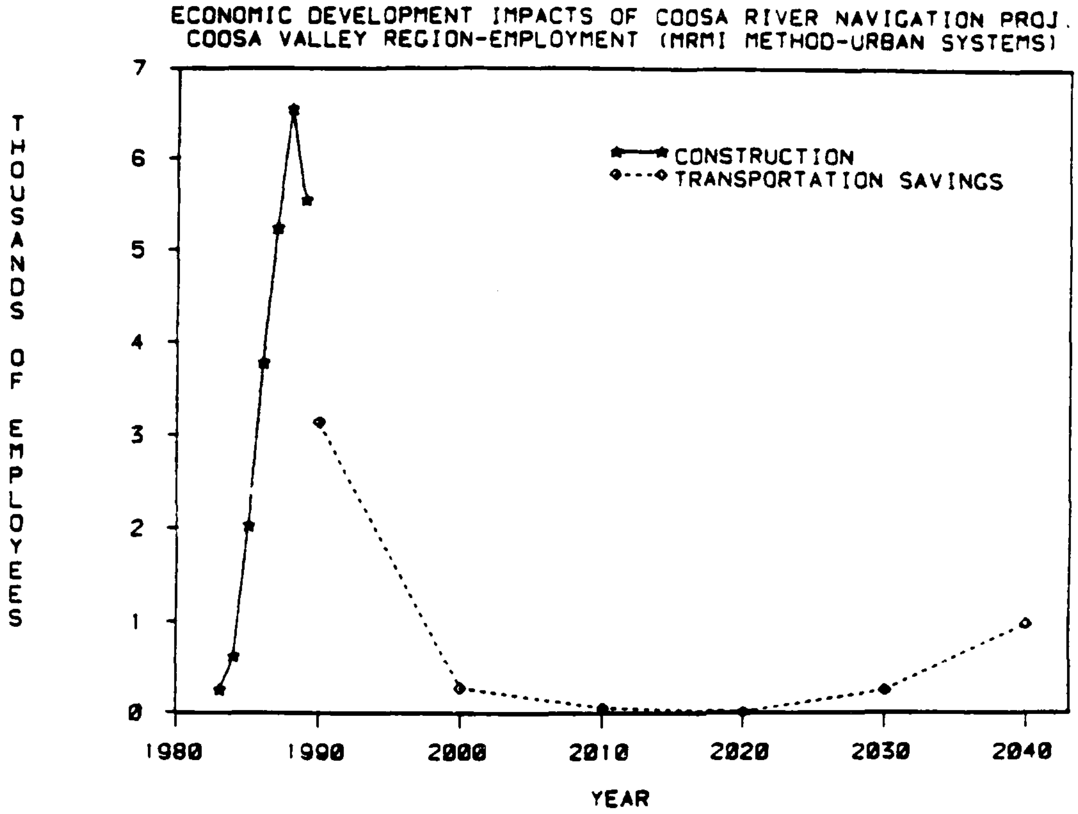


FIGURE 5


ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-EMPLOYMENT (MRMI METHOD-URBAN SYSTEMS)
THOUSANDS OF EMPLOYEES
0
1
2
3
4
5
6
7
CONSTRUCTION
TRANSPORTATION SAVINGS
1980
1990
2000
2010
2020
2030
2040
YEAR

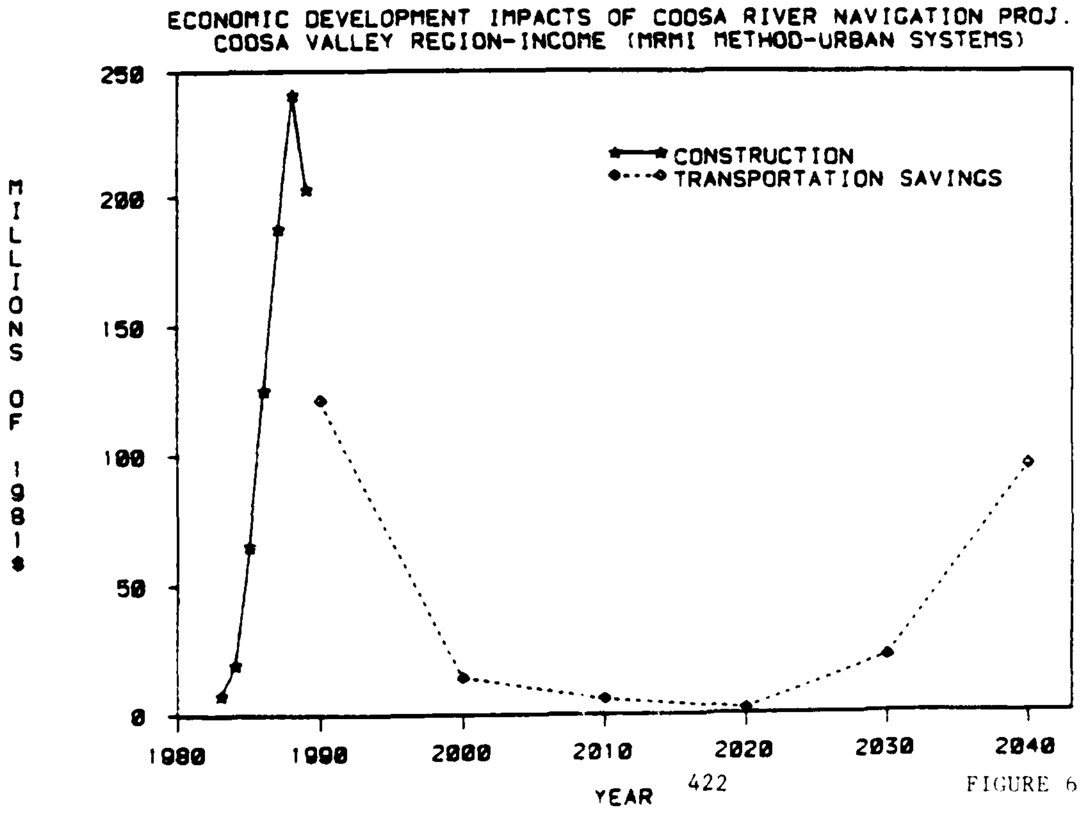

ECONOMIC DEVELOPMENT IMPACTS OF COOSA RIVER NAVIGATION PROJ.
COOSA VALLEY REGION-INCOME (MRMI METHOD-URBAN SYSTEMS)
MILLIONS OF 1981 $
0
50
100
150
200
250
CONSTRUCTION
TRANSPORTATION SAVINGS
1980
1990
2000
2010
2020
2030
2040
YEAR

FIGURE 6

Targeted Industries

SIC	Industries (Sensitive to Navigation Availability)	Average Site Size (in Acres)	Average Employment (per Site)
34941	Automatic Regulating & Control Valves	34	218
35623	Other Rolling Bearings, Complete	43	247
33574	Communication Wire and Cable	35	91
34233	Files, Rasps & File Accessories & Other Hand Tools	25	229
35857	Other Refrigeration & Air Conditioning Equipment	26	263
37991	Automobile Trailers (Excluding Housing Type Coaches)	21	106
24323	Softwood Plywood, Exterior Type	35	249
24326	Softwood, Venser	39	175
26217	Unbleached Kraft Packaging & Industrial Converting Paper	150	393
28182	Miscellaneous Acyclic Chemicals & Chemicals Products	102	277
33220	Malleable Iron Castings	41	289
34431	Heat Exchangers & Steam Condensers	28	249
35662	Speed Changers, Industrial High Speed Drives, & Gears	30	224
36426	Other Nonresidential Electric & Non-Electric Lighting Equipment	11	255
37321	Inboard Motorboats (All Types)	38	242
34790	Coating, Engraving, and Allied Services	11	213
34945	Metal Fittings, Flanges & Unions for Piping Systems	18	321
35481	Rolling-mill Machinery & Equipment	20	193
35314	Power Cranes, Draglines, Shovels & Parts and Attachments	30	356
35595	Other Special Industry Machinery & Equipment	26	227
36113	Other Electrical Measuring Instruments & Parts	16	282
38513	Miscellaneous Ophthalmic Goods	8	334

Source: PLANTEC Corporation, 1981.

Report of Survey of

Corps of Engineers

Construction Workforce

by

C. Mark Dunning

Institute for Water Resources
Water Resources Support Center
U.S. Army Corps of Engineers
Ft. Belvoir, VA 22060

June 1981

Research Report 81-R05

Copies may be purchased from:

National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22151

EXECUTIVE SUMMARY

Purpose

This survey of the Corps of Engineers construction workforce has two primary objectives:

a. To develop an empirical basis for determining employment benefits due to construction of Corps projects.

b. To develop an empirical basis for determining the socio-economic impacts of the workforce utilized for Corps project construction on local communities.

Payments to workers who would otherwise be unemployed (or underemployed) in the absence of a Corps project are called employment benefits. The Corps uses employment benefits in its benefit/cost calculations and has used them to influence priorities for new construction starts during periods of recession. These estimates have been attacked because they have in large measure been made with little empirical evidence to support them. A major goal of this study, therefore, was to develop credible empirical data for the calculation of employment benefits. A strong indication of whether workers would be otherwise unemployed in the absence of a Corps project is the length of time they have been unemployed prior to being employed on the construction project. Therefore, this study has developed information on the prior unemployment status of the contract construction workforce employed on Corps projects.

Project construction brings short term residents to local communities. These residents increase the demand for local public services, often without equivalent increases in local revenues. Communities sometimes request assistance to cure the alleged deficit and to help mitigate social stress which often comes with an influx of "outsiders." In order to manage these issues effectively, planners must have some means of estimating the size and demographic composition of a population in-migrating into local areas because of a Corps construction project. This report provides these estimates.

The survey used to generate the data base which is presented in this report was designed to be compatible with similar efforts undertaken by the Water & Power Resources Service (formerly Bureau of Reclamation) and Tennessee Valley Authority. The Economic Development Administration (EDA) undertook a major policy study which investigated the impacts of EDA construction grant projects on unemployment. Thus, the combined efforts of many agencies can lead to a more sound basis for assessing the impacts of Federal public works projects.

This study is based on a 51-project sample selected from 136 projects under construction during 1979. Over 65 percent of the

plans and at projects located in other EDA designated areas. This finding calls into question the rule restricting employment benefits to only EDA areas with redevelopment plans.

While EDA areas are designated on the severity and persistence of unemployment, it is likely that almost every local economy will have some structural problems and a pool of individuals who are out of work because of such imperfections. Survey findings show that although previous unemployment in non-EDA areas is less than in EDA areas, it is by no means trivial. This finding suggests that employment benefits may legitimately accrue to non-EDA designated areas as well.

Adjustments to unemployment figures obtained in the survey were made to factor our seasonal, discretionary, and frictional unemployment. Several tables were then generated using variables which analysis had shown to be associated with previous unemployment of the workforce. From these operations a table estimating previous unemployment of the workforce at Corps projects was generated (Table 1).

Estimating Demands on Local Community Services

The survey revealed that a large majority of the Corps' National construction workforce is composed of local workers (69.4 percent). White collar workers are much more likely to be non-local than either skilled or unskilled workers. Projects in the Western United States have higher proportions of non-locals employed than projects elsewhere in the country. Based on limited analysis, it appears that the proportion of non-locals employed on a project remains constant over the course of the construction project.

The proportion of the workforce at projects which is non-local is most closely associated with factors which influence a regions's ability to supply a pool of labor. For regions with smaller populations the proportion of non-locals employed on a project is greater. Regions which have higher rates to unemployment and which are EDA-qualified areas have a relatively greater pool of potentially employable local workers. These variables show modest negative association with the proportion of non-locals employed on a project. Regression equations were developed which predict the number of non-local workers employed on a project. The equations are likely to offer a useful means of estimating the number of non-local workers a project will employ.

Analysis of the non-local workforce characteristics reveals that, for the most part, non-local workers only expect to remain at their present location until the project is completed. Most workers bring dependents with them. Non-local workers, whether accompanied by dependents or not, try to locate as close as possible to the project site. Workers with dependents are also concerned with obtaining housing adequate for family needs. Housing choices for these workers are more likely to run to single family

construction workforce employed at the 51 projects at the time of the survey responded. The data base represents 4,089 complete responses from workers at a cross-section of Corps projects in various stages of completion and localities in varied local labor force conditions in 1979.

The following sections present the major findings of the survey. First are findings about the prior unemployment status of construction workers employed on Corps projects. Next are findings about the distribution of the workforce between local and non-local workers, as well as other characteristics of the workforce which would be useful for identifying the demand on local community services associated with Corps construction projects. Finally, an example is provided showing how findings from this study can be used to calculate employment benefits, and to assess the demands on local community services.

Unemployment Status of the Workforce

Of 4,089 workers responding to the question, 39.6 percent reported some unemployment immediately prior to beginning work on Corps projects. Clear differences in previous unemployment status were found among the workforce according to occupational group, locality, and the project area EDA status. Previous unemployment status showed no association with region or type of project. Unskilled workers are more likely to have been previously unemployed than skilled or white collar workers, and skilled workers have higher rates of previous unemployment than do non-local workers. Projects located in EDA areas have higher rates of workforce previous unemployment than do projects located in non-EDA areas.

Findings suggest that different factors are associated with previous unemployment for unskilled, skilled, and white collar segments of the workforce. For unskilled workers, remoteness of the project areas, as well as the region's general level of construction activity, are associated with previous unemployment. For skilled and white collar groups, previous unemployment is related to an ensemble of socioeconomic factors which give a region a less competitive edge; examples of these factors include EDA designation, below average educational attainment, and low per capita income. For all occupational groups the regional unemployment rate was strongly associated with previous unemployment.

Under current regulations, employment benefits are restricted to projects located in EDA designated counties which have approved redevelopment plans. These counties are a subset of all EDA counties declared eligible for EDA assistance; differing only in that they have an approved redevelopment plan. Survey findings show that significant numbers of otherwise unemployed workers are employed on Corps projects located in EDA areas, not only in EDA areas with redevelopment plans, but also in the other EDA designated areas. In fact there was no statistically significant difference in the proportion of previously unemployed workers employed at projects located in counties with approved redevelopment

Table 1. Estimates of Previous Unemployment

Project Area Location	Percent of Workforce Previously Unemployed		
	Local Workers		
	Unskilled	Skilled	White-Collar
EDA areas with regional unemployment rate of 6% or greater	42.7	32.8	22.1
EDA areas with regional unemployment rate of less than 6%	32.0	25.7	22.1
	Non-Local Workers		
	Unskilled	Skilled	White-Collar
All areas	32.0	21.3	22.1

and mobile homes than are the choices of workers with no dependents present.

In particular, the analyses suggest the following:

(1) Approximately 60 percent of the Corp's non-local workforce is accompanied by dependents.

(2) A ratio of 1.24 dependents to each non-local worker was computed. This ratio is independent of geographical area of the country where projects are located.

(3) A greater portion of non-local workers occupy more temporary types of housing (apartments, motels, boarding rooms, travel trailers) than local workers.

(4) For non-local workers, nearness to project site seems to be the most important housing choice location criterion.

(5) Less than one in three non-local workers intend to remain in the immediate vicinity of the project area after completion of the project.

Using survey data to calculate employment benefits and assess community service impacts.

Employment Benefits

The IWR Study has empirically documented the previous unemployment of the Corps construction workforce. The Table developed offers a means for estimating the employment benefits produced by a Corps civil works construction project. Inputs needed to develop such estimates are as follows:

- Number of workers by skill designation
- Locality of workforce by skill
- Location of project in terms of:

    County EDA status

    Regional unemployment rate

Each of these information inputs is discussed in greater detail below.

Number of Workers

An estimate of the number of workers to be employed on the construction project forms the base for calculating employment benefits. The methodology for deriving estimates of labor requirements for projects is beyond the scope of the present study; however, a number of sources for developing these estimates are

available. Among them are statistics maintained by the Bureau of Labor Statistics and WPRS on total dollar amounts of construction for various types of heavy construction activities and man-years of labor (Bingham, 1978; WPRS, 1980); and detailed statistics on construction project labor requirements compiled by F.W. Dodge Co. and made available in labor estimates produced by the Department of Labor's Construction Labor Demand System (Department of Labor, 1977).

Locality of Workforce

It has been shown that the previous unemployment of the workforce varies according to the variable of locality. Accordingly, the proportion of the workforce which is local and that which is likely to be non-local should be estimated. The regression equation in Table 3.12 of the survey report provides such an estimation of total numbers of non-local workers. Using Table 3.2, estimates of the occupational skill category of this workforce can be obtained. This Table indicates that for the national survey the non-local workforce was composed of 15.1 percent unskilled workers; 59.2 percent skilled and 25.7 percent white collar workers.

Location of Project

Two inputs are required. First, the EDA status of the county in which the project is to be constructed should be determined. Second, a regional laborshed for the project should be constructed using the procedure described in Section 1.3.1 of the report. The unemployment rate for this region can then be obtained from state employment or labor statistics departments.

The information and estimate developed above can then be used in conjunction with the appropriate tables shown in Table 1 of this summary to develop estimates of number of previously unemployed workers. Appropriate wage rates can be multiplied by these workers to yield estimates of employment benefits.

For example, assume a reservoir is to be constructed; assume a three-year construction schedule. Labor requirements of construction are: year 1 = 250; year 2 = 700; year 3 = 300 workers.

The estimated occupational distribution of workers is as follows:

	Construction Year		
	1	2	3
Unskilled	55	154	66
Skilled	160	448	192
White Collar	35	98	42
	250	700	300

To compute employment benefits, perform the following steps:

a. Locality of Workforce

(1) Estimate total non-local workers using regression equation:

Number year 1 =	.213 (PEAK*) -8.9 =	44
year 2 =	=	140
year 3 =	=	64

(2) Estimate occupational breakdown of non-local workers.

	Construction Year		
	1	2	3
Total non-local workers by occupational category	44	140	64
Number unskilled = 15.1% X Total	7	21	10
Number skilled = 59.2% X Total	26	83	38
Number white collar = 25.7% X Total	11	36	16
Total	44	140	64

Non-local workers

(3) Estimate occupational breakdown of local workers. Subtract non-local to obtain.

	Construction Year		
	1	2	3
Unskilled	48	133	56
Skilled	134	365	154
White collar	24	62	26
Total	206	560	236

Local workers

------

*where PEAK = number of workers required for construction year.

b. Location of Project

(1) EDA status: Assume county is located in EDA-designated area

(2) Regional unemployment rate: 6.9%

c. Compute Previous Unemployment

(1) Estimate previously unemployed local workers.

Year 1	Total local workers		Values from Table 1		Number Previously Unemployed
Unskilled	48	*	.427	=	21
Skilled	134	*	.328	=	44
White Collar	24	*	.221	=	5

(2) Estimate previously unemployed non-local workers

Year 1	Total Local Workers		Values from Table 1	Number Previously Unemployed
Unskilled	7	*	.320	2
Skilled	26	*	.213	6
White Collar	11	*	.221	2

(3) Repeat (1) and (2) above for construction years 2 and 3.

d. Compute a Wage Bill for Previously Unemployed Workers. Assume an "average wage" for occupational skill levels of \$8.00/hr, unskilled; \$13.00/hr. skilled; \$12.00/hr. white collar.

(1) Wage bill, year 1 = x+y+z where
x = Total number of unskilled workers previously unemployed * year 1 annual wage unskilled
= 23 * \$16,640 = \$382,720
y = Total number of skilled workers previously unemployed * year 1 annual wage skilled
= 50 * \$27,040 = \$1,352,000
z = Total number of white collar workers previously unemployed * year 1 annual wage white collar
= 7 * \$24,960 = \$174,720
x+y+z = \$1,909,440

(2) Compute wage bill for years 2 and 3 in same manner

(3) Compute total wage bill for previously unemployed workers by summing wage bills for years 1 through 3

(4) Add interest on wages paid to previously unemployed workers.

e. Compute Average Annual Employment Benefits

(1) Total employment benefits = total wage bill + total interest on wages

(2) Average annual benefits = total employment benefits * amortization factor. For example, total wage bill in this example = $9,549,280, total interest on wages = $887,190
amortization factor is .075914 assuming a 50 year project
life at 7 5/8 % discount rate
average annual employment benefits = $792,274.

Community Service Impact Assessment

The survey data analyses coupled with the comparative data assembled from other construction worker studies provide a solid empirical base to assess the demand on community services that a Corps project is likely to produce. The procedure for performing such an impact assessment using the survey data is shown in the example below.

As a planner for a Corps of Engineers reservoir project in final design stages, you have been asked by local governments in the reservoir project area to provide an assessment of the impact of the construction project on the community services in the project area. There are several small towns in the vicinity of the construction site and local governments are interested in identifying the range of likely benefits and costs the construction project will produce. What can you tell them?

Information provided by the survey can be used to perform a community impact assessment. The first step in such an assessment would be to calculate the number of non-local workers likely to be employed on the project. Using the regression equation in Table 3.12, an estimate can be produced. Assume that the relevant data for this equation were:

- Peak anticipated construction: 700
- Constant: 8.9
- Number of non-local workers : 140

Next, using the ratio ' 1.24 dependents per non-local worker obtained in Chapter 4, n estimate of 174 dependents is derived. Total population influx directly associated with the construction

project is thus estimated to be 314. Of the dependents, approximately 102 will be children and, of these 102 children, 79 will be school-age.

Housing needs of the incoming workforce can be projected using Tables 4.1 and 4.6. Here, the expected non-local worker population could be broken into 83 accompanied workers and 57 unaccompanied workers. Housing needs of these groups as expressed in Table 4.6 could be derived and matched with available supplies in surrounding communities.

Data strongly suggest that the communities located nearest to the project construction site will receive most of the total population influx of 314. Statements on the actual distribution of this population among nearby communities would have to be conditioned on separate assessments of supply of housing as well as on local government policies to attract or discourage incoming workers. Harnisch (1980), for example, found that one community adopted an aggressive policy to attract as many incoming workers as possible. In this community, zoning restrictions were relaxed and workers were exempted from paying local property taxes. Such policies should be factored into any assessment.

Having identified total worker-dependent influx and having made some judgment of settlement patterns informed by the survey data, as well as local conditions, an assessment of the impact of this influx on existing community services - schools, sewage systems, roads, etc. - can be made.

A method for performing this assessment developed by the Seattle District involves the following steps:

(1) Make "without project" population forecasts for local communities which are likely to be affected by construction-induced population increases.

(2) Inventory the "people capacity" of community services of these communities in relation to "without project" population forecasts.

(3) Allocate incoming populations to local communities on the basis of the survey data presented in this report, as well as on personal knowledge of the local area.

(4) Identify any shortages in community service capacities produced by, or worsened by, the influx of construction workers and dependents. Figure 1, showing how this information can be graphically displayed, is modeled off of a community impact study prepared by Seattle District (Harnisch, 1980). A forthcoming IWR report (Chalmers) provides detailed procedures for identifying, quantifying, and displaying community service impacts.

Data from the survey suggest that of the 140 non-local workers, 44 would remain in the local area after the project is

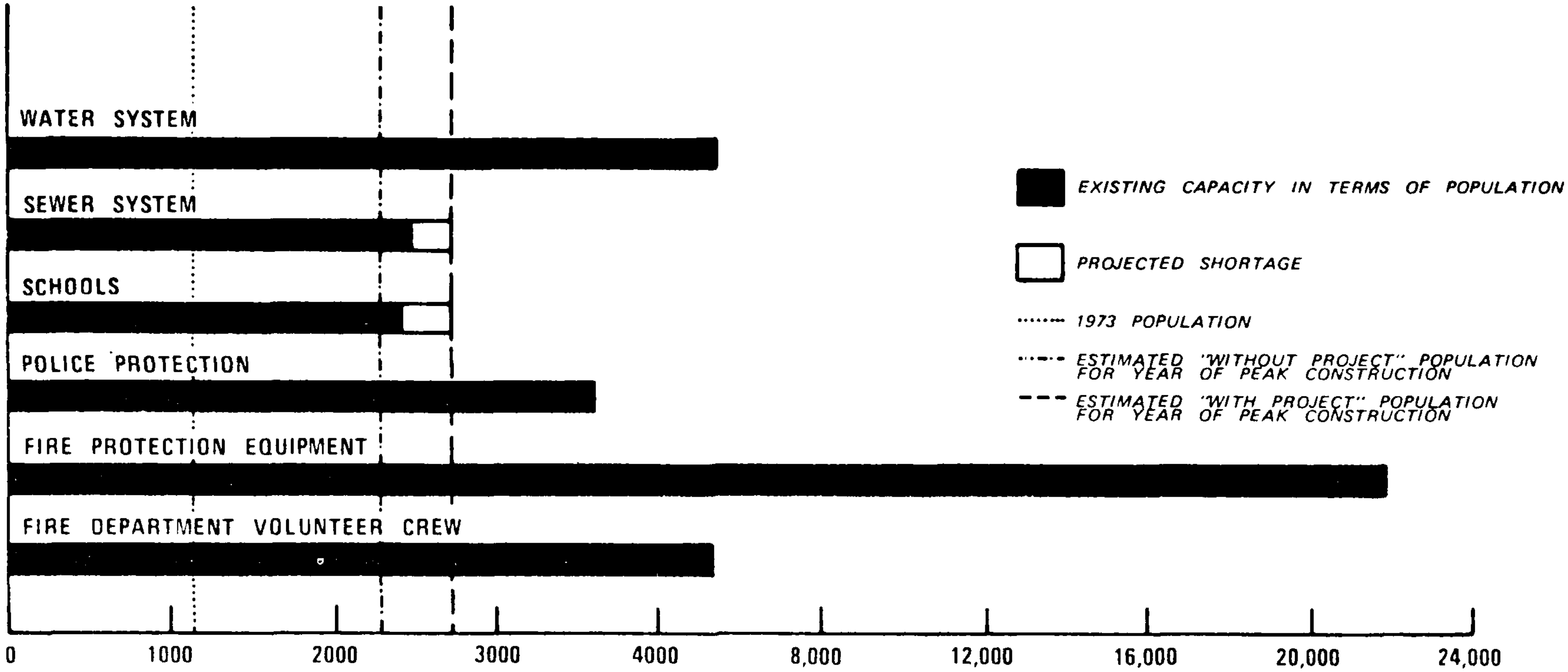


FIGURE 1: SAMPLE DISPLAY OF COMMUNITY SERVICE IMPACTS OF CONSTRUCTION GENERATED POPULATION INFLUX

completed. (Table 4.9.) Of these 44 workers, 26 accompanied workers are included representing about 81 persons, making a total number of individuals who are likely to remain in the local after completion of the project 99. This information can help local governments plan on the character of capital expense outlays for providing services to incoming workers.

Such information can provide Corps planners with the means to assist local governments in planning for and managing impacts associated with a Corps construction project.

It should be noted that the uncertainty concerning such community impacts is likely to be worse than the actual impacts themselves. For example, the "average" project in the current survey had 124 workers employed at the time of the survey. Of these workers, it is estimated that 40 were non-local. Assuming the ratio of 1.24 dependents per non-local worker, the average construction project brings only about 90 persons into the local area. In most local project areas, a population influx of this size would not produce appreciable community service impacts.

U.S. Army Corps of Engineers
Economic and Social Analysis Workshop
25-29 October 1982
St. Louis, MO

Office Assistant Secretary of Army for Civil Works

Dr. G. Edward Dickey

Office, Chief of Engineers

Dr. Lewis Blakey
Mr. Robert Daniel
Mr. John Burns
Mr. Kirby B. Fowler
Mr. William Counce
Mr. Richard Schultz
Mr. DuWayne Koch

Lower Mississippi Valley Division

Mr. Jesse K. McDonald
Mr. Charles E. Hill

Mephis District:

Mr. Ray Lartigue
Mr. Dave Bullock
Mr. Effort Alexander
Ms. Angelita Currie

New Orleans District:

Mr. Larry Prather
Mr. Tim Lookingbill

St. Louis District:

Mr. Rich Rodakowski
Mr. John Perulfi
Mr. Rich Anderson
Mr. Dennis Klosterman
Mr. Dick Mankus
Mr. Don Sweeney
Mr. Anson Eickhorst
Mr. Ed Ewanug
Mr. Jim Beregun
Mr. John Akery
Ms. Mary Orthwarth
Mr. Dan Marshall
Mr. Dave Macewan
Ms. Kathie Steinlagee
Mr. Dan Hawickhorst
Mr. Ron Lindsay
Mr. Roy Mathiesen
Mr. Dick Cameron

Vicksburg District:
Mr. Calvin Ashley
Mr. Bobby Learned
Mr. Robert Burke
Mr. Johnny Sanders
Mr. Joe McCormick

Missouri River Division

Mr. Curtis D. Musgrave

Omaha District:
Mr. Howard Thelen
Mr. Chris Knievel

North Atlantic Division

Mr. Edgar H. Lawson
Mr. Phillip J. Thorpe
Mr. Nahor B. Johnson

Baltimore District:
Mr. Charles Yoe

New York District:
Mr. Sam Tosi
Mr. Stanley Maisel
Mr. Norman Blumenstein

Norfolk District:
Mr. Frank Wooton
Mr. Tom Yancey
Mr. Mark Mansfield
Ms. Marian Huber

Philadelphia District:
Mr. Robert Selsor
Mr. Keith Harrington

New England Division
Mr. Steve Rubin

North Central Division
Mr. Harvey Kurzon
Mr. Denver Austin

Buffalo District:
Mr. Ron Guido

Chicago District:
Ms. Rose Austin
Mr. Dennis Giba

Rock Island District:
  Mr. Paul Soyke
  Ms. Fern Gaffey
  Mr. John Gray

St. Paul District:
  Mr. Dave Miller
  Ms. Jody Rooney
  Ms. Suzanne Gaines

North Pacific Division

  Mr. Ken Boire
  Mr. Frank McDonald

Alaska District:
  Mr. Chuck Welling

Portland District:
  Mr. Ken Cooper
  Mr. Joe Hise

Walla Walla District:
  Mr. Gary McMichael

Seattle District:
  Mr. Jim Smith

Ohio River Division

Louisville District:
  Ms. Sharon Bond
  Mr. Fred Bennett

Huntington District:
  Mr. Ron Keeney
  Mr. Vic Reck

Pittsburgh District:
  Mr. Joe Jones
  Mr. Chuck Moeslein
  Mr. Tom Scott

Nashville District:
  Ms. Frances Jones

Pacific Ocean Division
  Mr. William Hunt

South Atlantic Division

  Mr. Doug Belcher
  Mr. Harry Shaudy

Charleston District:
Mr Gerald Melton

Jacksonville District:
Mr. Marion Ritter

Mobile District:
Mr. Bill Hearrean
Mr. Alan Galdis
Dr. Claudia Rogers

Savannah District:
Mr. Peter Luisa

Wilmington District:
Mr. David Patchell

South Pacific Division

Mr. Frank Dunn
Dr. Norma Swenson
Mr. John Bogue
Mr. Walter Yep

Sacramento District:
Mr. R. Buff

San Francisco District:
Mr. R. Mooney
Mr. Gary Hershdorfer

Los Angeles District:
Mr. Norman Nierenberg
Mr. Joe Mantey

Southwestern Division

Mr. Ivan L. Hobson
Mr. Charles Armstrong
Dr. William Summitt

Fort Worth District:
Mr. William Fickel Jr.

Galveston District:
Mr. Frank Incaprera
Mr. Richard Curphey
Mr. William Wooley

Little Rock District:
Mr. Charles H. Lewandoski

Tulsa District:
Mr. Fred Munsell

Institute for Water Resources
- Dr. Lloyd G. Antle
- Ms. Arlene L. Dietz
- Dr. Arthur Hawnn
- Mr. David Bastian
- Mr. James Crews
- Mr. Michael Krouse

Waterways Experiment Station
- Dr. Victor Lagarde
- Mr. William Hansen

Hydrologic Engineeing Center
- Mr. Brian Smith

Construction Engineering Research Study
- Mr. John Fitipaldi

U.S. Fish and Wildlife Service
- Mr. John Loomis

American Waterway Operators
- Mr. Bob Goodwin

AGRI-TRANS, St. Louis
- Mr. Paul Staedeker

ARGONNE Laboratory
- Mr. Dick Winter

Wisconsin Department of Transportation
- Carol Cutworth
- Michael Kennedy

Illinois Department of Transportation
- Bruce Barker

☆ U.S. GOVERNMENT PRINTING OFFICE : 1983 O - 419-778

END

FILMED

2-84

DTIC